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OUR FORESTS.*

BY THEODORE ROOSEVELT.

If there is any one duty which more than another we owe it to our children and our children's children to perform at once, it is to save the forests of this country, for they constitute the first and most important element in the conservation of the natural resources of the country. There are of course two kinds of natural resources. One is the kind which can only be used as part of a process of exhaustion; this is true of mines, natural oil and gas wells, and the like. The other, and of course ultimately by far the most important, includes the resources which can be improved in the process of wise use; the soil, the rivers, and the forests come under this head. Any really civilized nation will so use all of these three great national assets that the nation will have their benefit in the future. Just as a farmer, after all his life making his living from his farm, will, if he is an expert farmer, leave it as an asset of increased value to his son, so we should leave our national domain to our children, increased in value and not worn out. There are small sections of our own country, in the East and in the West, in the Adirondacks, the White Mountains, and the Appalachians, and in the Rocky Mountains, where we can already see for ourselves the damage in the shape of permanent injury to the soil and the river systems which comes from reckless deforestation. It matters not whether this deforestation is due to the actual reckless cutting of timber, to the fires that inevitably follow such reckless cutting of timber, or to reckless and uncontrolled grazing, especially by the great migratory bands of sheep, the unchecked wandering of which over the country means destruction to forests and disaster to the small home makers, the settlers of limited means.

Shortsighted persons, or persons blinded to the future by desire to make money in every way out of the present, some-

*Extract from the President's Message, second session of the 60th Congress, December 8, 1908.

times speak as if no great damage would be done by the reckless destruction of our forests. It is difficult to have patience with the arguments of these persons. Thanks to our own recklessness in the use of our splendid forest, we have already crossed the verge of a timber famine in this country, and no measures that we now take can, at least for many years, undo the mischief that has already been done. But we can prevent further mischief being done; and it would be in the highest degree reprehensible to let any consideration of temporary convenience or temporary cost interfere with such action, especially as regards the National Forests which the nation can *now*, at this very moment, control.

All serious students of the question are aware of the great damage that has been done in the Mediterranean countries of Europe, Asia, and Africa by deforestation. The similar damage that has been done in Eastern Asia is less well known. A recent investigation into conditions in North China by Mr. Frank N. Meyer, of the Bureau of Plant Industry of the United States Department of Agriculture, has incidentally furnished in very striking fashion proof of the ruin that comes from reckless deforestation of mountains, and of the further fact that the damage once done may prove practically irreparable. So important are these investigations that I herewith attach as an appendix to my message certain photographs showing present conditions in China. They show in vivid fashion the appalling desolation, taking the shape of barren mountains and gravel and sand-covered plains, which immediately follows and depends upon the deforestation of the mountains. Not many centuries ago the country of northern China was one of the most fertile and beautiful spots in the entire world, and was heavily forested. We know this not only from the old Chinese records, but from the accounts given by the traveler, Marco Polo. He, for instance, mentions that in visiting the provinces of Shansi and Shensi he observed many plantations of mulberry trees. Now there is hardly a single mulberry tree in either of these provinces, and the culture of the silkworm has moved farther south, to regions of atmospheric moisture. As an illustration of the complete change in the rivers, we may take Polo's statement that a certain river, the Hun Ho, was so large and deep that merchants ascended it from the sea with heavily laden boats; to-day this river is simply a broad sandy bed, with shallow, rapid currents

wandering hither and thither across it, absolutely unnavigable. But we do not have to depend upon written records. The dry wells, and the wells with water far below the former watermark, bear testimony to the good days of the past and the evil days of the present. Wherever the native vegetation has been allowed to remain, as, for instance, here and there around a sacred temple or imperial burying ground, there are still huge trees and tangled jungle, fragments of the glorious ancient forests. The thick matted forest growth formerly covered the mountains to their summits. All natural factors favored this dense forest growth, and as long as it was permitted to exist, the plains at the foot of the mountains were among the most fertile on the globe, and the whole country was a garden. Not the slightest effort was made, however, to prevent the unchecked cutting of the trees, or to secure reforestation. Doubtless for many centuries the tree cutting by the inhabitants of the mountains worked but slowly in bringing about the changes that have now come to pass; doubtless for generations the inroads were scarcely noticeable. But there came a time when the forest had shrunk sufficiently to make each year's cutting a serious matter, and from that time on the destruction proceeded with appalling rapidity; for of course each year of destruction rendered the forest less able to recuperate, less able to resist next year's inroad. Mr. Meyer describes the ceaseless progress of the destruction even now, when there is so little left to destroy. Every morning men and boys go out armed with mattock or axe, scale the steepest mountain sides, and cut down and grub out, root and branch, the small trees and shrubs still to be found. The big trees disappeared centuries ago, so that now one of these is never seen save in the neighborhood of temples, where they are artificially protected; and even here it takes all the watch and care of the tree-loving priests to prevent their destruction. Each family, each community, where there is no common care exercised in the interest of all of them to prevent deforestation, finds its profit in the immediate use of the fuel which would otherwise be used by some other family or some other community. In the total absence of regulation of the matter in the interest of the whole people, each small group is inevitably pushed into a policy of destruction which cannot afford to take thought for the morrow. This is just one of those matters which it is fatal to leave to unsupervised individual control. The forests

can only be protected by the State, by the Nation; and the liberty of action of individuals must be conditioned upon what the State or Nation determines to be necessary for the common safety.

The lesson of deforestation in China is a lesson which mankind should have learned many times already from what has occurred in other places. Denudation leaves naked soil; then gullying cuts down to the bare rock; and meanwhile the rock-waste buries the bottomlands. When the soil is gone, men must go; and the process does not take long.

This ruthless destruction of the forests in northern China has brought about, or has aided in bringing about, desolation, just as the destruction of the forests in central Asia aids in bringing ruin to the once rich central Asian cities; just as the destruction of the forests in northern Africa helped towards the ruin of a region that was a fertile granary in Roman days. Shortsighted man, whether barbaric, semicivilized, or what he mistakenly regards as fully civilized, when he has destroyed the forests has rendered certain the ultimate destruction of the land itself. In northern China the mountains are now such as are shown by the accompanying photographs, absolutely barren peaks. Not only have the forests been destroyed, but because of their destruction the soil has been washed off the naked rock. The terrible consequence is that it is impossible now to undo the damage that has been done. Many centuries would have to pass before soil would again collect, or could be made to collect, in sufficient quantity once more to support the old-time forest growth. In consequence the Mongol Desert is practically extending eastward over northern China. The climate has changed and is still changing. It has changed even within the last half century, as the work of tree destruction has been consummated. The great masses of arboreal vegetation on the mountains formerly absorbed the heat of the sun and sent up currents of cool air which brought the moisture-laden clouds lower and forced them to precipitate in rain a part of their burden of water. Now that there is no vegetation, the barren mountains, scorched by the sun, send up currents of heated air which drive away instead of attracting the rain clouds, and cause their moisture to be disseminated. In consequence, instead of the regular and plentiful rains which existed in these regions of China when the forests were still in evidence, the unfortunate inhabitants of the de-

forested lands now see their crops wither for lack of rainfall, while the seasons grow more and more irregular; and as the air becomes dryer certain crops refuse longer to grow at all. That everything dries out faster than formerly is shown by the fact that the level of the wells all over the land has sunk perceptibly, many of them having become totally dry. In addition to the resulting agricultural distress, the watercourses have changed. Formerly they were narrow and deep, with an abundance of clear water the year around; for the roots and humus of the forests caught the rainwater and let it escape by slow, regular seepage. They have now become broad, shallow stream beds, in which muddy water trickles in slender currents during the dry seasons, while when it rains there are freshets, and roaring muddy torrents come tearing down, bringing disaster and destruction everywhere. Moreover, these floods and freshets, which diversify the general dryness, wash away from the mountain sides, and either wash away or cover in the valleys, the rich fertile soil which it took tens of thousand of years for Nature to form; and it is lost forever, and until the forests grow again it cannot be replaced. The sand and stones from the mountain sides are washed loose and come rolling down to cover the arable lands, and in consequence, throughout this part of China, many formerly rich districts are now sandy wastes, useless for human cultivation and even for pasture. The cities have been of course seriously affected, for the streams have gradually ceased to be navigable. There is testimony that even within the memory of men now living there has been a serious diminution of the rainfall of northeastern China. The level of the Sungari River in northern Manchuria has been sensibly lowered during the last fifty years, at least partly as the result of the indiscriminate cutting of the forests forming its watershed. Almost all the rivers of northern China have become uncontrollable, and very dangerous to the dwellers along their banks, as a direct result of the destruction of the forests. The journey from Pekin to Jehol shows in melancholy fashion how the soil has been washed away from whole valleys, so that they have been converted into deserts.

In northern China this disastrous process has gone on so long and has proceeded so far that no complete remedy could be applied. There are certain mountains in China from which the soil is gone so utterly that only the slow action of the ages could

again restore it; although of course much could be done to prevent the still further eastward extension of the Mongolian Desert if the Chinese government would act at once. The accompanying cuts from photographs show the inconceivable desolation of the barren mountains in which certain of these rivers rise—mountains, be it remembered, which formerly supported dense forests of larches and firs, now unable to produce any wood, and because of their condition a source of danger to the whole country. The photographs also show the same rivers after they have passed through the mountains, the beds having become broad and sandy because of the deforestation of the mountains. One of the photographs shows a caravan passing through a valley. Formerly, when the mountains were forested, it was thickly peopled by prosperous peasants. Now the floods have carried destruction all over the land and the valley is a stony desert. Another photograph shows a mountain road covered with the stones and rocks that are brought down in the rainy season from the mountains which have already been deforested by human hands. Another shows a pebbly river-bed in southern Manchuria where what was once a great stream has dried up owing to the deforestation in the mountains. Only some scrub wood is left, which will disappear within a half century. Yet another shows the effect of one of the washouts, destroying an arable mountain side, these washouts being due to the removal of all vegetation; yet in this photograph the foreground shows that reforestation is still a possibility in places.

What has thus happened in northern China, what has happened in Central Asia, in Palestine, in North Africa, in parts of the Mediterranean countries of Europe, will surely happen in our country if we do not exercise that wise forethought which should be one of the chief marks of any people calling itself civilized. Nothing should be permitted to stand in the way of the preservation of the forests, and it is criminal to permit individuals to purchase a little gain for themselves through the destruction of forests when this destruction is fatal to the wellbeing of the whole country in the future.

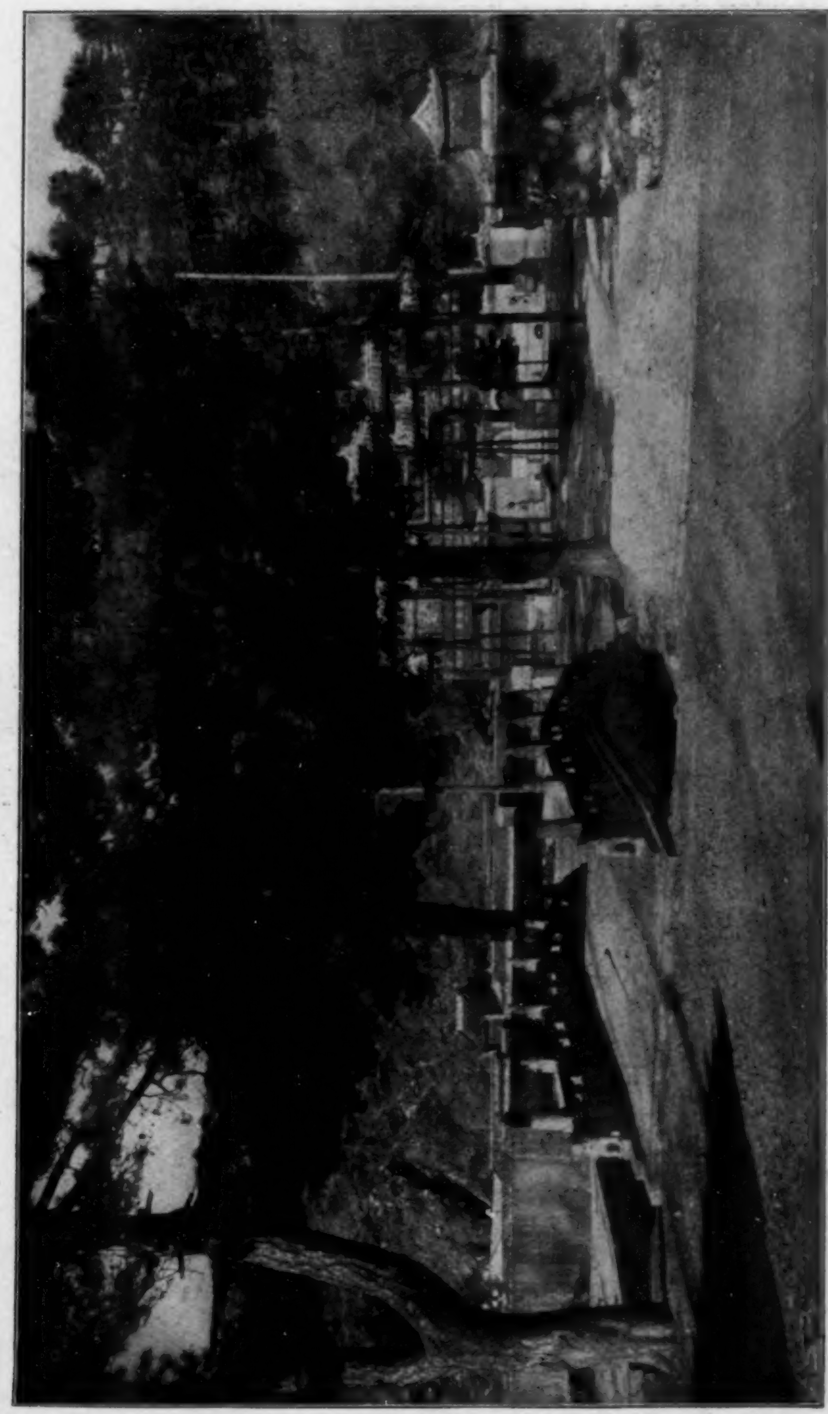
No. 1.—Two Hundred Square Miles of Once Wooded Mountains Which a Century Ago Paid Rich Revenue on Their Lumber Product

Locality: District of Fou-ping, Chili Province, China. View from the top of a mountain 2,000 feet high, looking down on adjacent hills and valleys.

Bailey Willis, January, 1904.

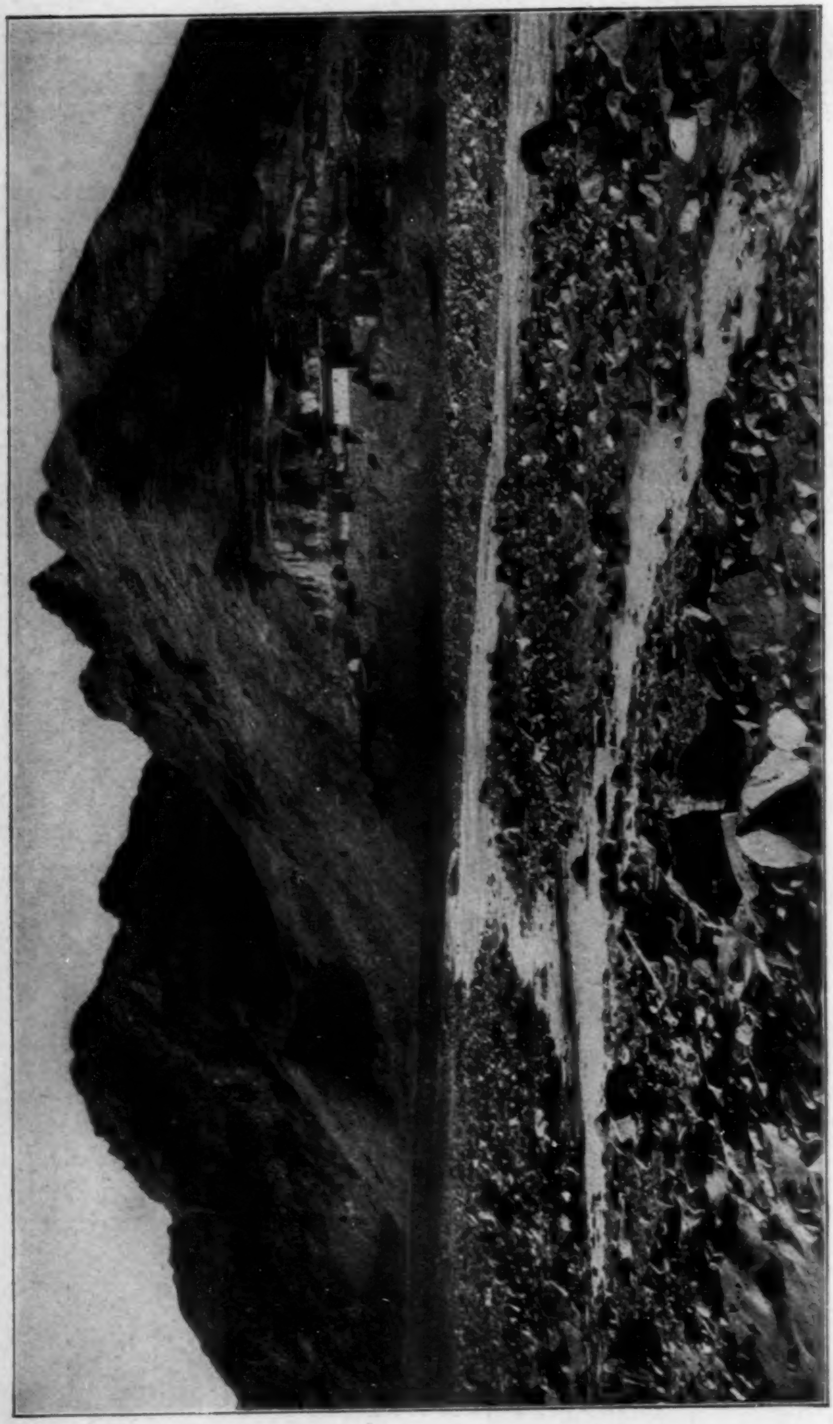
No. 2.—Chief City in a District Formerly Rich in Timber

Locality: Fou-ping district, Chili Province, China. View across the valley of the Ta-Sha-ho (Big Sandy River), including the city of Fou-ping and the neighboring mountains of gneiss, a region closely resembling in situation and physical conditions the Piedmont district of the Appalachians from Virginia to Georgia.
Bailey Willis, January, 1904.



No. 5.—Trees Remain Only Where Protected in Temple Grounds

Locality: District of Wu-t'ai-shan, northern Shan-si Province, China. Bailey Willis, January, 1904.



No. 6.—Bottom Lands Buried in Waste from the Deforested Mountains

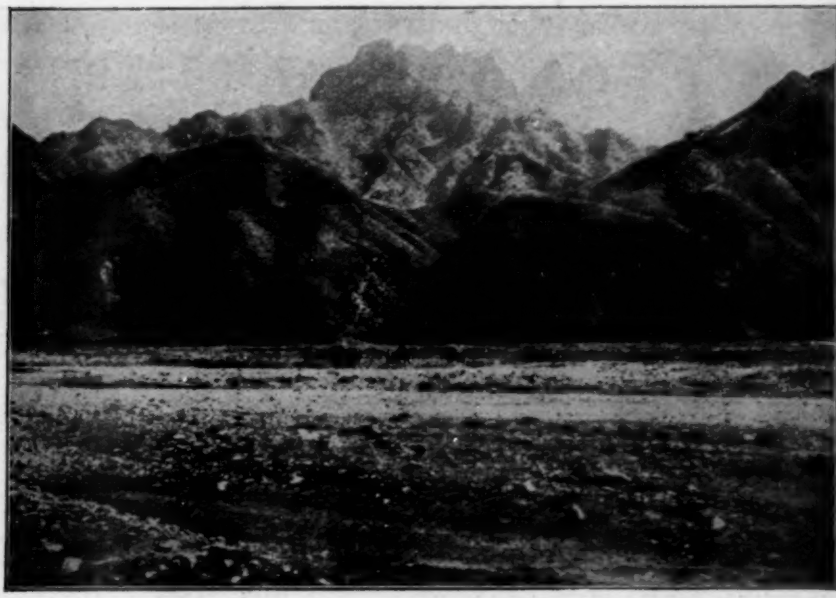
Locality: District of Wu-t'ai-shan, northern Shan-si Province, China. Bailey Willis, January, 1904.

No. 7.—Saving What is Left of the Soil When the Forests are Gone. Artificial Terracing

Locality: District of Wu-t'ai-shan, northern Shan-si Province, China. Bailey Willis, January, 1904.

No. 8.—Farming in the Path of the Flood

Locality: District of Wu-t'ai-shan, northern Shan-si Province, China. A valley at the base of the mountains which during the spring rains is covered by flood waters. The stone walls catch some of the sediments and crops are grown on the soil thus saved. Bailey Willis, January, 1904.



No. 9.—Caravan Passing Through a Valley Where Formerly Prosperous Peasants Used to Live When the Mountains Were Still Forested

Locality: Near the Wu-t'ai-shan, Shan-si, China. The floods have carried destruction all over the land, and its aspect is like a stony desert. April 14, 1907.

No. 10.—A Pebbly River Bed in South Manchuria

Locality: Near Fong huang sheng, South Manchuria. The formerly big stream has dried up, on account of the climate having become more arid since the destruction of the forests on the mountain sides. Only some scrub wood is left, which will disappear within the next 40 or 50 years. June 27, 1906.

AN ANCIENT DUODECIMAL SYSTEM.

By Rufus P. Williams.

"A pint's a pound the world around."

This aphorism is approximately true of water, so nearly true that it was regarded absolutely so by our ancestors. If a pint is a pound, then a quart weighs two pounds and 32 quarts or 64 pints weigh 64 pounds. But a cubic foot of water also weighs 64 pounds, hence a cubic foot was equivalent to 64 pints. Now the correlation of these three facts is interesting—64 pints, 64 pounds and one cubic foot of water are equivalent each to the other, or a cubic basin one foot long, wide and high holds 64 pints, which weigh 64 pounds. Was this accidental, or was it design? In dry measure 32 quarts make a bushel. Dry and liquid measure were once the same in content, though now differing considerably. As it is the fact rather than the name we wish to emphasize, the word bushel is used in the following table. A linear foot was divided into 12 parts called inches, a square foot containing 144 square inches and a cubic foot 1728 cubic inches.

The following table exhibits the successive dual divisions of the numbers mentioned:

1 bushel,	or 64 pints,	contains 1728 cubic inches,	and weighs 64 pounds.
1/2 bushel,	or 32 pints,	contains 864 cubic inches,	and weighs 32 pounds.
1/4 bushel,	or 16 pints,	contains 432 cubic inches,	and weighs 16 pounds.
1/8 bushel,	or 8 pints,	contains 216 cubic inches,	and weighs 8 pounds.
1/16 bushel,	or 4 pints,	contains 108 cubic inches,	and weighs 4 pounds.
1/32 bushel,	or 2 pints,	contains 54 cubic inches,	and weighs 2 pounds.
1/64 bushel,	or 1 pint,	contains 27 cubic inches,	and weighs 1 pound.

It should be said that the 8 pints given above, or 216 cubic inches, are not the present imperial gallon, which contains 10 pounds of water, in which "a pint of pure water weighs a pound and a quarter."

Let us turn now to linear measure. The foot was divided into 12 equal parts called inches. Twelve is divisible by 2, 2, and 3. The cubic foot of 1728 cubic inches is an extraordinarily good number to subdivide. Besides being a perfect cube it can be divided by 2, 2, 2, 2, 2, 2, 3, 3, 3, or $(2)^6 x (3)^3$. It is divisible by the cube 64, giving a quotient of 27, another perfect cube. To repeat, the curious facts summarized in the above table are: 64 is divisible by 2 as many times as 1728 is; 64 pints contain

1728 cubic inches, or 1 pint is 27 cubic inches, and 1 pound (of water) also fills 27 cubic inches. These numbers, 12, 1728, 64, 27, therefore, bear a peculiar relation to one another, and are the most perfect numbers to correlate in this manner which could have been selected, so perfect, in fact, that one cannot avoid the conclusion that some clever and practical mathematician invented this system of weights and measures, which is a combination of the duodecimal and dual systems. To contrast this system with the decimal let us suppose our philosopher had employed the decimal system and divided the foot into 10 inches. The cubic foot would have contained 1,000 cubic inches, which number is exactly divisible by 2 only three times instead of six times, as in case of the duodecimal 1728. In the same way he could have divided 100 pints or 100 pounds by 2 only twice, instead of 6 times, as in the number actually used, 64. The following table illustrates the point:

1 bushel or	100 pints, or	1,000	cu. in. (water)	would weigh	100 lbs.
½ bushel or	50 pints, or	500	cu. in. (water)	would weigh	50 lbs.
¼ bushel or	25 pints, or	250	cu. in. (water)	would weigh	25 lbs.
⅛ bushel or	12½ pints, or	125	cu. in. (water)	would weigh	12½ lbs.

If he had called 1,000 cubic inches 1,000 pints and the weight 1,000 pounds, even then but 3 divisions by 2, instead of 6, could have been made. Looked at from this standpoint alone the duodecimal system of weights and measures, as well as of numbers, appears greatly superior to the decimal, but this is only one viewpoint, and takes no account of decimal notation.

Let us now try to imagine how this mathematical philosopher worked out his problem, for thus we may gain an insight into the origin of the duodecimal system. The foot was the starting point, and it was originally derived from the length of the pedal organ of some person, real or imaginary, as the foot measure was almost universal in early civilizations. Our philosopher, knowing the three dimensions of space and the relations of square and cubic to linear measure, conceived the idea of correlating also volumetric measure and weight to the lineal foot. Had he gone no further and disregarded subdivision, the decimal would have served equally well, and he would naturally have selected 10 as his unit, instead of 12. But, noting that the cubic foot of water (or wine) must be subdivided, he found from the multiplication table that no number up to 12 (with the

possible exception of 8, which is an inferior number to 12 as a basis) would give a cube capable of such perfect subdivision successively by 2, as would 12. Twelve was therefore selected as a division of the foot, the smallest subdivision that at the time was deemed necessary. This quotient was called the inch (from the Latin word *uncia,* a twelfth part). In fact, the word shows the origin of the idea. Our word *ounce* is also a derivative of *uncia,* and means the twelfth part of a pound. A square foot must therefore contain 144 square inches, and a cubic foot, 1,728 cubic inches. Having found a number whose cube could be divided six times by two, he would naturally construct a 1,728-cubic inch basin, then make vessels containing successively the half, quarter, eighth, etc., parts, obtaining at last the conveniently small quantity—the pint. This was as low as it was carried, for it was the last dual subdivision of 1,728, and, further, it is a conveniently small volume of water or wine. The pint held 27 cubic inches.

Again, seeing the utility of correlating weight with volume, he counterpoised the pint of water and named its weight a pound (from *pondus,* a weight). Multiplying the pint and pound as many times as he repeated the 27 cubic inches, he arrived at 64, the whole secret of the combination being the selection of 1,728, or, rather, its cube root, 12. The early pound had 12 ounces, not 16. Thus did the ancient philosopher work out a most perfect duodecimal system of weights and measures.

Professor Conant in his admirable work on *The Number Concept,* as well as Lubbock and other anthropologists, have shown how strongly the decimal system of counts from the ten fingers persisted in most early races and formed the basis of our system of numbers. Had our savage ancestors chosen as wisely as the ancient philosopher, and counted 12 instead of 10 as a radix, the two would have been invented as perfect a working system as the science of numbers admits. The savage chose not wisely, and the two systems, decimal and duodecimal, are as unblending as oil and water. To attempt to harness the duodecimal or any other system of weights and measures to a decimal notation is to break up the duality of both, one of which must eventually give way. When Herbert Spencer opposed the Metric System on the ground that the duodecimal notation was better than the decimal and would some time supersede the latter, he could not

have counted upon the hold that decimalization has taken on the whole human race.

Though we cannot name this Newton of antiquity, the inventor of so clever a system, we may with much probability trace his nationality. Our system, of course, was derived from England. Whence did she derive hers? Definite English laws about weights and measures take us back little further than 1266, when the second *Magna Charta,* relating largely to uniform weights, was forced from Henry III. So many changes have since been made in the subdivisions of these measures that it is difficult to recognize the Simon-pure article in the original. That these weights and measures came originally from the ancient Romans is shown alike by the similarity of derivation and their correlation. Their foot, for example, had the same origin as our own, though in the lapse of ages the English foot has become longer than its old prototype. The old Roman also correlated length and capacity measure by making a cubic foot of water or wine, and naming it an amphora. And, moreover, they called an eighth of an amphora a congius. For grain, etc., the term quadrantal was used, which, also, had the capacity of a cubic foot. Thus the amphora or quadrantal corresponded to our bushel, and the congius to our gallon. Owing to the shortness of their foot, the capacities of the above measures are not now coincident with those of our own, but this in no way affects the harmony of relation.

The Romans, however, were not a mathematical people. They employed letters—Roman numerals—in place of Arabic figures. as a result of which they never originated much in mathematics. Like the English, the Romans were borrowers. We have unquestionable evidence that their arithmetic came from Babylonia. Here in the valleys of the Tigris and Euphrates are now found the oldest known remains of civilization, extending back perhaps 5000 years, B. C. On slabs of baked clay are recorded the history of the times and of a people enlightened in mathematics and astronomy.

The versatility of Babylonian mathematicians is shown by their familiarity with the use of the dual, the duodecimal, and the sexigesimal systems, in addition to the decimal. To this people, then, we are lead to believe we owe the once perfect duodecimal system of weights and measures.

But not alone were the Babylonians concerned with such measuring. Measurements of the circle, the year, the day, were problems which they solved and handed down to us. Whence came the sexigesimal system, in which 60 is the radix? Probably from two sources. First, from the division of the circle; second, from that of the year. Dividing the circle into six equal parts by three diameters, and connecting the extremities so as to form triangles, they found every angle equal to every other, every side equivalent to every other, every triangle equal to every other triangle. There were six of each of these, but while six was not a number to subdivide, its multiple by ten—that is, 60—is a fair one, and 360 for the entire circumference, a better one. Besides, this number most clearly corresponded to a complete yearly cycle, 360 days being the length of their year.

The parts of the circle of 360° cut off by the extremities of two consecutive diameters form a sixth part of the entire circumference. or 60°, called a sextant. Each of the sixty degrees was again divided into 60 parts called minutes, and each minute into 60 other parts called seconds. This sexigesimal system of the circle runs as follows:

Sixty seconds make one minute.
Sixty minutes make one degree.
Sixty degrees make one sextant.
Six sextants make one circumference.

The year was divided duodecimally into 12 months. The week is another question, not connected with our discussion.

Such was the Babylonial division of the circle and the year. But even more interesting is the division of the day, for in that they made use of the dual, the duodecimal, and the sexigesimal systems. A complete day, from one sunrise to the next, was divided into two parts, from sunrise to sunset, and from sunset to sunrise, or, into day and night. The day they divided into 12 parts, and the night the same, this being exactly true only at the vernal and autumnal equinoxes, with which the Babylonian astronomers were familiar. In subdividing the hour, recourse was again had to the sexigesimal system, as also in the division into minutes. Why 12 parts instead of 60 were made the day measure we can only guess, but in that conjecture we see how much simpler is reckoning by 12 than would have been by 60. The "time" table is too familiar to everyone to be repeated here.

but twelve hours per day and 12 per night gave us the 24 hours per day. Most clocks, except astronomical ones and those of a few European railroads, are still marked off into 12 hours. The clepsydra, or water-clock—similar in principle to our sand-glass—served among the Mesopotamians, as among the Greeks and Romans, for marking the subdivisions of the day, though the sundial was also in use. Few things illustrate better the persistence of custom than the fact that we use the identical system of numbers which these people employed 5,000 years ago, for measuring time. Clever indeed was the mathematician who, so many years ago, invented the perfect system of duodecimal weights and measures, and wise the ruler who forced its use on the people.

The sexigesimal arithmetic has to a large extent disappeared, and the duodecimal is slowly following in its wake. The English people have probably never had the latter system in its purity, as did the inhabitants of the Euphrates and Tigris, but each system will eventually go out of existence, because neither is in harmony with the world-wide decimal scheme of numbers.

No one, unless he be a time-server, if he carefully studies the history of weighing and measuring, can doubt that the International Metric System, founded on the universal notation, is the coming system. The mathematician of the distant future will read with amazement that early in the 20th century there were so-called civilized people who used a system in which 5½, 272¼, and other equally absurd numbers were bases of reckoning—a system far inferior to that of the old Babylonians, 5,000 years earlier.

AN ECOLOGICAL SURVEY OF THE DRIFTLESS AREA OF ILLINOIS AND WISCONSIN.

By H. S. Pepoon, M.D.,

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(Continued from May issue.)

Species of Northern and Southern Distribution.

The area has from remote time been uncovered by the primeval waters, so that the surface has suffered merely the modifications due to erosive agencies of air and water; it might then with reason be expected that a commingling of southern and northern species would exist, and with all the more assurance because of the midway latitude of 42 degrees. During the long lapse of time some southern forms would gradually adapt themselves to a colder climate and some northern species would reverse the process. This is exactly what is found. For an astonishing example, the Pecan (Hicoria pecan) may be named. A notoriously warm temperate tree, it is yet found in the Mississippi bottom in the area, just on the 42° line, attaining a height of 90 feet, and a diameter of 3 feet, copiously fruiting also. The Coffee bean is locally common, particularly along the bluffs of the great river. The Mulberry (Morus rubra) is frequent along the Apple River, and was found in full fruit in 1908.

Not ten rods away from groups of the two latter species, Canoe Birch, Primrose, Moose-Wood (Dirca), Wild Snowball, and other cold temperature forms were common. It is true that the narrow gorge of Apple River is an exceedingly sheltered locality, both from heat and cold, and plants from either clime, by choosing the proper exposure, would easily find a genial temperature environment. Still it is no less interesting and noteworthy that they do grow in juxtaposition.

In the larger report, of which this is but a summary, a careful analysis of the geographic center of distribution of each of the 936 listed species is made, with the following approximate results, subject to modification as the completed survey of 1909 may affect it.

Plants of northern distribution and center of development, 20%.
Plants of western distribution and center of development, 3%.
Plants of southern distribution and center of development, 5%.

Plants of eastern distribution and center of development, 18%.
Plants of central distribution and center of development, 46%.
Plants of introduced distribution and center of development, 8%.

It is worthy of remark in connection with northern plants that the temperature of Jo Daviess county is lower than for any other part of Illinois, often reaching a minimum of 20°-40° below zero. This may account for the large proportion of plants of colder regions that are found jostling with the mixture from other sources.

EXAMPLES OF ISOLATED SPECIES AND PECULIAR HABITAT.

On all the mounds mentioned in a preceding paragraph, a more or less isolated flora is found. A few examples must suffice to illustrate this point. The Canoe Birch is common. Nowhere else were the following species found, viz., Putty Root (Aplectrum); Pipsissewa; Anychia canadensis; Botrichium obliquium; Aquilegia; Campanula rotundifolia and Pulsatilla hirsutissima also reach here their best development. Several grass species are also peculiar to the barren and dry knobs and exposed faces of these elevations. Putty Root has been found by me in three places, first on Benton Mound, in this area (one plant); second on the clay lake bluff at Highland Park, Ill., and third, in Van Buren County, Mich., in beech woods, no two localities having the same environment. This is a hard problem in distribution to solve.

Cases of peculiar habitat are abundant. Three or four very striking ones may be given, all contrary "to the books." The showy Lady-slippers (Cypripedium reginae) of "swamps and woods" grow here invariably on the bluffs, and some specimens sent to the Missouri Botanical Gardens were actually clinging to a crevice in a vertical limestone cliff. The only specimen of Limodorum (Grass Pink) found was on the bald crown of a high bluff, which place yielded Leptorchis loesellii or Twayblade; no Limodorum of "bogs and meadows" or Leptorchis of "wet thickets and springy banks" was found. The Fringed Gentian is a common cliff plant; this, however, must be noted, that abundant seepage of water constantly bathes the roots of all the above, and an explanation is given in the next paragraph. Shrubby Potentilla, a bog plant in Michigan, is a cliff plant here. White Pine grows nowhere but on the dry clefts of towering cliffs. Here, too, but lower down, the Wild Snowball grows,

but only here, "low woods" say the books. Moose-wood (Dirca) is to be sought for on the bluffs; "woods and thickets" the books have it.

It appears to me that these peculiarities of habitat have a reasonable explanation in a gradual adaptation of the several species to life in far different topographic environment, but having a similar water content in the soil. This change in habitat may be a striking example of the effect of the removal of the fierce competition in the open bog or thicket, a few forms seemingly, discovering the practical immunity from such struggle on the cliffs and adapting themselves to life there.

This has been done even at the expense of precarious foothold and lesser food supply. Here, then, we might expect to find the last stand of many ancient as well as modern forms of plant life. The only place where the three confers, Pine, Red Cedar, and Yew, many ferns, several orchids, three liliaceous plants, the Primrose, and many more are to be found, is on these, to man often unattainable, cliff homes.

The Border Between Drift and Driftless.

While but little difference appears to exist in the plants of the upland varieties on the prairies, everywhere the topographic feature of the border between the two areas, one feature deserves particular mention, and that is the very sudden increase in number of pond and swamp forms, brought about by the imperfect drainage of the drift. The ponds, swamps, and wet prairies abound in sedges, juncus, potomogetons, polygonums, utricularias, naumbergias, and many more species entirely absent from the other side of that magic line, the drift margin. The prairies of drier nature are crowded with forms that reach their best development here, although many species are spread over the higher open lands within the Driftless area. The Meadow and the Turk's-Cap Lily abound, and astonishing to a degree, the White Fringed Orchis (Blephariglottis leucophoea) exists by thousands. The prairie Ranunculus, Violets, Phlox, Gentiana puberula, the cream-colored Wild Indigo, Asclepias sullivantia, Blazing Stars, and hordes of other original prairie plants greet the eye.

In this connection it is worth while noting the preservative influence of the Illinois Central R. R. on plant life. Built through this region in 1858, the right of way has never been cultivated, and the only unfavorable factor is the annual *burning*

off in August. This comes too late to injure in the least spring and early summer forms, and even many Asters and late season types find havens of safety about telegraph posts and in the fence rows. It is here that genuine prairie plants are to be found, and a number of species are not to be obtained elsewhere. Of course migrant plants are much in evidence, and probably two thirds of all introduced species can be found bordering the track bed. The purple Cone Flower, petioled Sunflower, False Dandelion (Nothocalais), Prairie Gentian (G. puberula), and Polygala incarnata are examples of species not seen in other localities. The weeds from the railroad initial vantage ground spread outward, and thus slowly take possession of waste places.

Sand Prairie.

In the sand area of the southwest portion of Jo Daviess county, bordering on the Mississippi River, a strip ten miles long by one to two miles wide, there exists a very peculiar and interesting community of plants, partaking in many of their features of the characteristics of desert plants. The land is a level plain, or with occasional minor elevations, having two well-marked zones of elevation, the low and the high prairie, a sand bluff bordering on the Mississippi, and a dune immediately inland from the bluff. A cross-section from river to valley bluff shows six zones of plant life, each markedly differing from the others, except zones two and three.

Zone one is the alluvial bottom land covered by Sand-bar Willow, Polygonums, Iron-weed and associated growths; zone two is the abrupt sand bluff, having a slope of about 40° and a maximum height of about 100 feet. Here White Ash, Sycamore, Hop-tree (Ptelea), Honey Locust, and Thorn Apples are woody growths, and Day Flower (Commelina), Partridge Pea (Cassia), Froelichia, Diodea, Polygonum geyeri, and several grasses are peculiar. The dune, which is generally narrow, and from 20 to 40 feet above the high prairie, has largely a similar flora but the Black Oak is the abundant tree, and many herbaceous forms are found in the shaded depressions and on the landward slope. Among these the noteworthy one from the distribution standpoint is Cristatella, native of the far west and southwest.

Beyond the dune, and varying from a mere fringe to one fourth of a mile, is the Black Oak belt of the upper prairie, or

the third zone of plant life. Here beside the oak are the gramma grasses, Anychia, Rhus Aromatica, Goats-rue (Cracca), Opuntia, and Dwarf Dandelion (Adopogon). Much of the soil is bare and excessively dry at all times. The open, elevated *prairie* was a waste originally, covered with a host of sand-loving plants, some very striking, as the Opuntias, Chrysopsis, Plantagos aristata and Purshii, Synthyris bullii, Horsemint (Monarda punctata), Puccoons (Lithospermum), Evening Primroses, Poppy Mallow (Callirhoe triangulata), Croton, Yellow Linum, Pasque Flower, and others too numerous to list. The Xerophytic characters are markedly common.

The lower prairie has a somewhat similar vegetation, but lying 40 feet or more lower, has much more abundant moisture, receiving also the overflow bluff drainage, there being no drainage lines from the ravines debouching from the great border bluffs to the river. A number of new forms, many of far western plants, are found on this lower prairie and add beauty to the far spreading level. Foxgloves, Amorphas, Bush-clovers, Poppy Mallows, Rock Roses, Oxalis, Polygalas, Blue-eyed Grasses, are characteristic forms. The Burlington R. R. traverses this level and has introduced many western and southwestern forms. One, Lotus americanus, seems, however, to act like a native, so abundant is it, but far from its recorded habitat.

The whole prairie marks a former level of the great river, when it flowed four miles wide from the ice land at the north, and this was in comparatively modern times, geologically. The surface has since been eroded by the wind, numerous blowouts with their peculiar plant forms, notably, Cristatella, Talinum, and several grasses being common present features. Three hundred and fifty species were found upon this prairie during the year of 1908, of which 20 were peculiar to the bluff and dune, 10 to the oak belt, 25 to the high, and 15 to the low prairie, the balance being generally scattered, although many species are very rare, and only a few specimens found. As a whole this prairie reminds me of the elevated plains of northwestern Nebraska and South Dakota, having many plants identical or of related species. In fact, a number of species seem to have had their original home on these western lands and by some means have found their way far to the eastward.

Comparison.

The proportion of plants found in different plant associations or societies has not been fully worked out, but approximately the results are shown in the following tabulated form:

Drift Area—

No. of Species.	Prairie.	Woodland.	Bluff.	Sand.	Water.
850	250	445	40	15	100

Driftless Area—

No. of Species.	Prairie.	Woodland.	Bluff.	Sand.	Water.
936	25	641	140	100	30

In the table the introduced plants are scattered among the various associations.

Summary and Conclusion.

It is expected that 1909 will swell the above total to 1,050 species, the vast majority being pure woodland types or those found on the timbered bluffs. Only about 3% are prairie or water forms, while about one tenth are peculiar to the southwestern sand area. The north has contributed the largest number of species, outside of those of universal range. All the data seems to bear out the assumption that the land is old and that forms have been intermingled from all directions, and finding favorable environment have established themselves permanently. Further, provided there be suitable water amount for the root system, habitat, according to the books, means little and is often contradicted, species being found in the most unlooked for situations. Bluff and cliff flora are apparently asylums of many species that have found safe refuge from destructive agents that have driven them out of their original haunts. Isolated sand areas, like *Sand prairie*, afford splendid opportunity to study the effect of environment on plant features and structures, pure desert characteristics being found in neighborhoods normally plentifully supplied with water. And, more than all, the completeness and complexity of land drainage affects most profoundly the forms and distribution of plant life.

Many matters remain untouched or but inadequately treated, all of which will receive their full merits in the Report that goes to the Missouri Botanical Gardens, for whose benefit the work was undertaken. It is hoped that the season of 1909 will see the completion in satisfactory manner of the whole undertaking.

WHAT SHALL WE TEACH CONCERNING THE PHYSIOLOGICAL EFFECTS OF ALCOHOL?

By Harry Clifford Doane.

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(*Continued from May issue.*)

Dr. Henry Leffman, professor of toxicology and hygiene at the Woman's Medical College of Pennsylvania, remarks: "It is often said that alcohol is a food, but in such an expression the word 'food' is not used in the sense with which it is employed in ordinary language." In an address before the Academy of Medicine at Buffalo Dr. T. D. Crothers, superintendent of Walnut Lodge Hospital, Hartford, Conn., said: "Alcohol is among the most poisonous and seductive drugs which can be used in medicine, and as a beverage it occupies much the same plane as that of opium to quiet pain and discomfort, and nothing more."

Effect of Alcohol on the Ability to Resist Disease.—In experiments on over three hundred animals, including dogs, rabbits, guinea pigs, fowls, and pigeons, Laitenen of the University of Helsingsfors and Professor Frankel of Halle found that alcohol without exception made these animals more susceptible to disease than were the controls. Dr. T. Alexander MacNicholl, in a recent address said: "Massart and Bordet, Metchnikoff and Sims Woodhead have proved that alcohol, even in every dilute solution, prevents the white blood corpuscles from attacking invading germs, thus depriving the system of the coöperation of these important defenders, and reducing the powers of resisting disease. The experiments of Richardson, Harley, Kales and others have demonstrated the fact that one to five per cent of alcohol in the blood of the living human body in a notable degree alters the appearance of the corpuscular elements, reduces the oxygen bearing elements, and prevents their reoxygenation."

Emphasis is frequently placed on the destruction and deterioration of the leucocytes or white blood corpuscles by writers on the subject. Dr. Grosvener, quoted above, declares: "The poisoning and paralyzing influences of alcohol lead to the conclusion that the alcoholized organism presents a lessened resistance to the attacks of micro organisms. The detailed experiments of Abbot upon lower animals lean strongly toward the

same conclusion. His experiments upon rabbits showed that the normal vital resistance to some organisms was markedly diminished. * * *

"Rubin as reported in *Journal of Infectious Diseases,* May 30, 1904, studied the effect of alcohol upon infectious disease as shown in rabbits. He found that the number of leucocytes was much less in alcoholized than in the control rabbits, that as soon as the leucocytes began to decrease the bacteria increased, that there existed a negative chemotoxis."

Use of Alcohol in the Treatment of Disease.—In the London Temperance Hospital alcohol was prescribed seventy-five times in thirty-three years. The death rate in this hospital has been lower than that of most general hospitals. Sir William Collins, after serving nineteen years as surgeon in this hospital said: "In my experience, speaking as a surgeon, the use of alcohol is not essential for successful surgery. * * * At the London Temperance Hospital, where alcohol is very rarely prescribed, the mortality in amputation cases and in operation cases generally is remarkably low. Total abstainers are better subjects for operation, and recover more rapidly from accidents, than those who habitually take stimulants."

Dr. S. A. Knopf says: "Alcohol does not cure tuberculosis! Used in excess and injudiciously administered, it surely retards recovery." Dr. Legrain, senior physician to the asylum, Ville Evrard, Paris, declares: "The systematic treatment of chronic tuberculosis by alcohol is apparently a physiological absurdity."

In the same article from which I have already quoted Dr. MacNicholl says: "During a period of ten years the Chicago hospitals in which alcohol was employed in pneumonia showed a death rate of twenty-eight to thirty-eight per cent. Nonalcoholic medication during the same period at the Mercy Hospital showed a death rate in pneumonia of less than twelve per cent. * * * The mortality in our hospitals bears a very close relation to the per capita of alcohol prescribed. In the Fordham Hospital where seventy-two cents per capita of alcohol is prescribed, one out of every eight patients who enter for treatment dies. In the German Hospital, Philadelphia, where forty-three cents per capita of alcohol is prescribed one of every sixteen patients die. In the Red Cross Hospital, New York City, where no alcohol is prescribed, one out of one hundred and four patients die."

In a paper read at the International Congress on Tuberculosis, in New York, 1906, Dr. Crothers remarked that alcohol as a remedy or a preventive medicine in the treatment of tuberculosis is a most dangerous drug and that all preparations of syrups containing spirits increase, rather than diminish, the disease.

Dr. Kellogg says: "The grave significance of the effects of alcohol upon living cells can be fully appreciated only when we keep in mind the fact that phagocytosis is the chief means of bodily defense against bacterial disease. It is only through leucocytosis—the migration of leucocytes, and their activity in attacking and destroying bacteria—that recovery from any infectious disease is possible. The paralyzing influence of alcohol upon the white cells of the blood—a fact which is attested by all investigators—is alone sufficient to condemn the use of this drug in acute or chronic infections of any sort."

Experience of Insurance Companies.—The United Kingdom Temperance and General Provident Institution of London insures in two departments, a general section and one for total abstainers. During the sixty years from 1841 to 1901 there were 31,776 whole-life policies in the general or non-abstaining section. These passed through 446,943 years of life and there were 8,947 deaths. In the abstaining section there were 29,094 whole-life policies, passing through 398,010 years of life, with 5,124 deaths. If the death rate in the abstaining section had equaled that in the general section there would have been 6,959 deaths instead of 5,124, or the mortality averaged 36 per cent higher in the non-abstaining section than in the abstaining section.

In his article published in the book by Horsley and Sturge, Dr. Arthur Newsholme says: "Out of every 100,000 starting at the age of twenty, among the abstainers 53,044 reach the age of 70, while only 42,109 reach this age in the general experience of a large number of life offices of Great Britain."

Of 100,000 total abstainers starting at twenty

53,044 reach 70 years; 46,956 die before 70 years

Of 100,000 moderate drinkers starting at twenty

42,109 reach 70 years; 57,891 die before 70 years

In the Scottish Temperance Life Assurance Society, in the

twenty years ending 1897, the deaths amounted to 69 per cent of the expected mortality in the general section, while in the total abstainers' section they amounted to only 47 per cent of the expected number. The number of deaths in the general section of the Sceptre Life Association, England, was 80.34 per cent of the expectation in the fifteen years ending 1898, but in the total abstainers' section it was only 56.37 per cent of the expected mortality.

In considering the statistics of the insurance companies it is well to remember that those insured in the general sections were picked men as well as those in the total abstainers' sections.

In discussing the experience of fraternal societies, Dr. Newsholme gives the following statistics from the report of the Public Actuary of South Australia:

	Average Mortality Per Cent	Average Sickness in Weeks
Abstainers' Societies	0.689	1.248
Non-abstainers' Societies	1.381	2.317

	Mortality Per Cent of Sick Members	Average Weeks of Sickness Per Each Member Sick
Abstainers' Societies	3.557	6.45
Non-abstainers' Societies	6.532	10.91

Attention should be called to the fact that the "non-abstainers'" societies have many members who are total abstainers, but unlike the "abstainers'" societies they do not refuse to admit non-abstainers. The number of weeks of sickness in the table refers to the average number of weeks for which the members call upon the sick fund of the society.

Fermented Liquors.—Many people seem to have an impression that the danger in alcoholic beverages is limited to the use of distilled liquors and that no harm can follow the moderate consumption of wines, beers and the like. Most of the results and conclusions in the preceding paragraphs have to do with the effects of small amounts of alcohol, not with the excessive use; hence the absurdity of exempting fermented liquors from the list of noxious drinks. It may not be amiss, however, to take some testimony directly on this point.

In Dr. Norman Kerr's great work, "Inebriety or Narcomania," he says: "So far from being an innocent and healthful article of diet, beer, stout, 'et hoc genus omne' are noxious and unwholesome luxuries, with no practical food value, and by their vitiation of the blood a fertile cause of degeneration, disease

and premature death." Again: "Of the cases which have been under my own observation, while one gallon a day has been a moderate allowance, I have known eight gallons consumed in one period of twenty-four hours. The general average per day has been one-half gallon. I have, however, seen intractable disease and premature death result from less than a quarter of this quantity drunk daily over a term of years."

After a careful investigation Professor G. O. Higley, professor of chemistry Ohio Wesleyan University, declares: "If we leave out of consideration for the moment the injurious effects upon the system of even small amounts of alcohol, we shall find that the united fuel value of the solids and alcohol in beer is comparatively slight, only about one-thirtieth of that obtained from flour costing the same money!"

Professor Guttstadt of Berlin publishes statistics showing that in Prussia of every 1,000 deaths of men over twenty-five years, 161 are from tuberculosis. Of every 1,000 deaths among bartenders, 556 are from tuberculosis; among brewery employees, 345; school teachers, 143; physicians, 113; clergy, 76. The 55th annual report of the British Registrar General gives the average death rate of England as 13 per thousand, but among brewers it is 41 per thousand, only four occupations showing a higher rate.

Dr. Henry Didama, for many years dean of the Medical College of the University of Syracuse, in an address, in 1902, discussing beer, wine and porter said: "As disease and crime producers they are a close second to ardent spirits in the vicious race." Dr. Gudden, in a German medical journal declares that the typical beer drinker either dies of heart disease or other diseases in which beer is a factor, or he is compelled by the setting in of these diseases either to give up or to greatly reduce his beer allowance.

Dr. George D. Haggard of Minneapolis has shown by many analyses that a large number of the so-called "malts," "malt extracts," and "tonics," including several of the best known and most advertised on the market, are simply disguised beers and frequently very poor beers at that.

Summing up the evidence with regard to the effects of alcohol in small amounts, even much less than the amount usually consumed by the so-called moderate drinker, we may briefly state our conclusion as follows:

1. Alcohol causes an expansion of the capillaries giving a sense of warmth to the skin, but with actual lowering of the body temperature, at the same time weakening the heart's action.

2. It acts as a narcotic poison, paralyzing the brain and nerves, deadening the sense of pain and fatigue with consequent false sense of renewed vigor, diminishing the acuteness of all the senses with corresponding tendency to recklessness and lack of control of actions. Then follows a feeling of satisfaction with mediocre results from all kinds of effort.

3. Muscular power is markedly diminished.

4. Healthy digestion is not aided by alcohol and it seriously interferes with impaired digestion.

5. It destroys and paralyzes the white blood corpuscles, greatly lessening the ability of the body to resist and throw off disease.

6. Alcohol is never a food, but always a narcotic poison, having, as do other poisons, a tendency to form an unnatural appetite.

7. It shortens life.

8. It is a dangerous drug and should be used very sparingly, if at all, in the treatment of disease and then only in definitely prescribed doses. It can by no means be considered a safe family remedy.

9. The continued use of alcohol, even in amounts no larger than that in from one to three glasses of beer taken daily, causes accumulative effects, ultimately bringing about cell change and tissue degeneration, either producing actual disease or so lowering the tone of the body as to make it more susceptible to disease.

These conclusions are stated conservatively and we can teach them to our pupils with the assurance that they are in essential agreement with the results obtained by those physiologists who, by their own investigations and experiments, are qualified to speak authoritatively. The serious and far-reaching results following the larger use of alcoholic liquors is too well known to need discussion here. It is certainly the duty of every grade teacher and every teacher of physiology and chemistry to teach the truth concerning alcohol.

A FUNDAMENTAL PRINCIPLE WHICH SHOULD DETERMINE THE SEQUENCE OF TOPICS IN ELEMENTARY CHEMISTRY.

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The writer is one of those who believes that every teacher can teach more effectively according to a plan of his own—if he has had a chance to elaborate the details—than he can teach according to anybody else's plan. Hence this paper is given with no intent to present a complete plan and details of an elementary course in chemistry for others to follow. Although such a plan appears below, it is given here to show how the fundamental principle to which attention is to be called in this paper may be built upon.

Every plan is or should be elaborated in accordance with some fundamental principles. If we may judge from the text-books in use these principles are comparatively few in number. Professor Alexander Smith[1] classifies them as follows: The nature study method; the theoretical method; and the historico-systematic method. It appears to me that the text-books used most extensively in America are arranged in accordance with this third method. This method, says Professor Smith, "is an arrangement with reference to chemical materials, with the theory distributed at convenient intervals. The order seems to be determined in the first place by a desire to conform to the historical development of the subject. Oxygen, air and water thus find an early place. This *motif* presently gives place to the impulse to arrange the elements in accordance with the natural families."

The fundamental idea of this method and the historical beginning as presented in most texts is quite acceptable, but the arrangement of the material farther on whether in accordance with the natural families, or any other plan which considers *primarily* a classification of the materials leaves much to be desired. The object seems to be to arrange the course with the view of telling something *about* chemistry, rather than to develop in the students the ability to handle the subject in the attitude of the working chemist. While I do not intend to make a professional

[1]Smith & Hall, "The Teaching of Chemistry in Physics," page 53 and following.

chemist of every high school student who enters upon this work, yet I believe that the student should learn to handle his stock of acquired facts so that he may apply them to the solution of problems, as far as this may be practicable. The students' attention should be directed more particularly upon the means of attaining certain results, rather than upon the results themselves. A system of arrangement which considers primarily the arrangement of the materials may be very serviceable for a handbook or an encyclopedia, but it is likely to be ill suited for the purpose of setting forth the chemical reactions with which the substances were produced. In one sense, of course, the materials produced are of prime importance, but no one will affirm that a knowledge of the material, however extensive it may be, can be sufficient for a chemist: to the contrary, it is a knowledge of the *tools* and of the details of their action and effects which a man must have to be a chemist. Again I hear the protest: our object is not to make chemists. Then I ask, What about your attitude in the teaching of mathematics? In the teaching of Latin? In the teaching of English? Do you aim to teach *about* these subjects or do you aim to develop an ability to handle these subjects? Do you aim to teach the students *about* the quadratic equation, or do you train them to solve problems involving quadratic equations? The answer to the latter is unequivocal. Then why should there be any doubt or difference of opinion in the answer to the question on chemistry?

The trend of research during the present and immediate past is towards a careful study of the details of reactions. These studies, while they may not have resulted in the production of new chemical substances to any marked degree, have served to improve the old methods of preparation or have pointed out new or better methods, and above all they have systematized our knowledge of the interaction of chemical substances, and without this further research and progress would be difficult. It is but in keeping with this spirit of modern chemical progress that some detailed study of the reactions should be introduced in the elementary work. Whatever has proven itself to be a leading and fruitful idea in the subject has always been introduced to some degree in elementary work. The emphasis given to Avogadro's Hypothesis is evidence in this connection. Of course, I would not urge incorporating any extremely recent and half-tried idea, but I would urge the introduction of ideas and sub-

jects which have been accepted by the great mass of chemists, for instance, the electrolytic dissociation theory with the subservient notions of *concentration, mass action, relative solubility,* etc. I would not *parade* these on one or two "state occasions"; I would *base* the whole method of presentation upon some of these well established facts and theories.

To attain these ends I consider that it is necessary to study the reactions themselves and the conditions affecting them, and the simplest sort of pedagogy requires that the study of the reactions should be progressive. I would urge that the progressive study of reactions should be a fundamental principle of arrangement. The following may serve as an example:

1. Simple reactions of combination or decomposition;
2. Metathetical reactions;
3. Complex reactions involving oxidation and reduction.

The topics ordinarily included in an elementary course are arranged so that the reactions exhibited by the substances come after the general principles and conditions affecting these reactions have been demonstrated carefully. To show how this may be done I will give an outline of a course designed upon this principle of arrangement, with which course I have attained what appears to me to be satisfactory results during the last ten years.

The course begins with the topics, oxygen, hydrogen and water, treated in the manner in which they are usually treated. These topics have proven themselves particularly suitable for a beginning, and the reactions they introduce are quite simple—which is of prime importance in this outline. Hydrochloric acid is studied next, and the simplicity of the metathetical reaction is pointed out. Chlorine is introduced after hydrochloric acid, partly out of deference to the old order of arrangement, though strictly speaking it is out of place here. It is introduced merely for descriptive purposes, and the reactions involved in its preparation are not considered in detail: it is insisted that the action consists of the oxidation of the hydrogen of the hydrochloric acid to water, thus liberating the chlorine. The next topic, acids, bases and salts, is dwelt upon at length because it gives an excellent opportunity for drill in some of the fundamental characteristics of the metathetical reactions, such as constancy of the valences of the elements and radicals involved, the *binary* character of all acids, bases and salts, and the fact that two sub-

stances through reaction produce just two others. All this admits of a great deal of beneficial drill in formula and equation writing. The list of substances considered under this topic is made as extensive as possible. Not only are soluble bases presented, but also insoluble bases, and the connection between hydration and solubility is pointed out, etc. Thus two important general reactions have been brought before the student, namely, the reaction between acid and bases, and hydration and dehydration; and the primary characteristics of the metathetical reactions have been emphasized. The topics: ammonia, carbon and carbon dioxide, sulphur and sulphur dioxide (with hydrogen sulphide and sulphuric acid merely for descriptive purposes) are next introduced. Sulphur dioxide is prepared by a metathetical reaction, that is by liberation from a sulphite with an acid. It is readily seen that the three topics just mentioned present many instances of metathetical reaction (that is, in their liberation from salts) of hydration and dehydration, and of neutralization. Immediately following this, the general facts concerning a number of oxy-acids (the *ion* formulæ, the extents of hydration—shown by the dualistic formulæ—the solubilities, etc.) are briefly introduced, with very little or no experimental work.

The next topic is the general consideration of the metathetical reaction in solution. For this purpose a list of the solubilities of the common salts is given, which, with the solubilities of the acids and bases previously given, completes this part of the information. The existence of the reversible reaction is then demonstrated. For this purpose I have used a mixture of sodium chloride and nitric acid, which reacts to produce some hydrochloric acid and sodium nitrate. By means of a piece of aluminium foil it is easy to show that sodium chloride and nitric acid actually undergo reaction, because each substance alone does not react readily with aluminium, whereas the mixture reacts quite readily. In the same way, by means of a piece of copper foil, it may be shown that sodium nitrate and hydrochloric acid react when mixed. Of course, this does not prove that one mixture reacts to produce exactly the components of the other, but it shows enough to predispose the student to accept the rest of the information on faith—as in most demonstrations. The effect of concentration next remains to be considered, for which purpose the reactions between ferric chloride and potassium sulfo-cyanate may be employed. The extent of

electrolytic dissociation of acids, bases, and salts is then given in the usual brief form. This is followed by a drill exercise on forming precipitates by mixing two solutions which contain an effective concentration of the ions of the insoluble combination, etc.

The next topic taken up in the laboratory is the action of potassium or sodium hydroxide upon solutions of salts of all the common metals. All possibilities that may arise in this connection are pointed out; for instance, the dehydration of the precipitated hydroxide or its dissolution in excess of the reagent. In a similar manner the action of ammonia and of the soluble sulphides are taken up. Other reagents, however, are not introduced one by one, but they are introduced in connection with an outline for the separation and identification of a limited number of the common metals. This outline is adapted from the ordinary outline for the determination of bases in qualitative analysis. It is constantly stressed in this connection that the object is not the analysis of any *unknown,* though such work may be included in the exercise, but that the object is to teach the reactions of the common reagents with compounds of the common metals. Most of the reactions met with in this work are metathetical, and involve the *general* principles which have been pointed out in detail. Side by side with this work the student studies the descriptive portions of the text, found usually in the chapters on the metals; for instance, under sodium, potassium, copper, magnesium, zinc, calcium, barium, strontium, aluminium, iron, nickel, gold, silver, and mercury.

Here and there in the preceding work, oxidation and reduction reactions will be met. The student is told that their discussion will come later. At some convenient point, usually before all of the preceding work has been past, a general discussion of oxidation and reduction phenomena is introduced. The topics used in this connection are the displacement of one element by another, such as the displacement of hydrogen in acids by metals or the precipitation of copper, mercury, or tin from their salt solutions by other metals. Next would come the dissolution of metals in nitric acid; the action of nitric acid on hydrides, such as hydrochloric acid, hydrogen sulphide, etc., and finally the oxidation of ferrous to ferric salts, mercurous to mercuric salts, etc. Beyond this point the order in which other topics are introduced is a matter of small concern, because the student is prepared to understand the new facts presented.

The main point in connection with this latter part is a *system* for discussing these O. & R. actions. Several systems are in use at present: one is found illustrated in A. A. Noyes' "Qualitative Analysis;" a second in Alexander Smith's "College Chemistry;" a third in Prescott & Johnson's "Qualitative Analysis;" and a fourth is found in Talbot & Blanchard's "Dissociation Theory;" in Boettger's "Qualitative Analysis;" and possibly in several other books. It may be designated as the electrochemical system, which is used exclusively in all journal articles on physical and electrochemistry. I do not wish in any way to decide between the relative merits of these systems, but I would urge above all that some one system be adopted and carefully presented. The significance of the term *oxidizing agent* must be accurately understood by the student. Without it the expression that chlorine is a strong oxydizing agent or that hydrogen sulphide is a strong reducing agent, etc., can scarce be intelligible to the student. The system should enable the student to figure out readily the *amount of oxidation* or *reduction* that any particular element undergoes in passing from one compound to another (e. g., of chlorine in passing from hydrochloric acid to potassium chlorate). Hence some unit must be employed to express this relation. In Professor Smith's book the unit employed (though it is not explicitly so called) is the oxygen or the hydrogen atom. Thus when nitrogen changes from nitric acid to nitrous oxide, it is reduced four "oxygens" per two HNO_3; when a nitrate is reduced to ammonia, the change is eight "hydrogens" per one HNO_3; etc. Johnson's method makes use of a specially defined oxidation "bond" as the unit. In the electrochemical system, the unit is the unit electrical charge. Thus for the examples given above we have:

(1) $2NO_3^- + 8\ominus = N_2O + 5\,O^{--}$

(2) $NO_3^- + 5\ominus + 4H^+ = NH_4^+ + 3\,O^{--} + 3\oplus$

which becomes

$NO_3^- + 4H^+ = NH_4 + 3\,O^{--} + 8\oplus$

As per (1), the change of 2 nitrate ions to nitrous oxide requires the addition of eight negative unit charges (reduction) per two nitrate ions; and (2) shows that the charge requires the *removal* of eight *positive* charges (also reduction:) per one nitrate ion. The estimating of the relation of two states of oxidation of an element and expressing it in terms of some unit is exceedingly

important. When this is once mastered, it is easy to complete the drill in the use of any system by pointing out that the amount of oxidation must be equal to the amount of reduction, etc. Finally, it must be made clear to the student that such a system serves merely to express or relate facts that have been learned elsewhere, but that it cannot and does not teach the facts themselves. The student must seek to remember the facts apart from the system, and he must learn the facts in an extensive manner. Thus, having learned that copper in its action on dilute nitric acid will reduce the latter to nitric oxide, and knowing that zinc has a great solution tension, he should infer that zinc would reduce the acid of same concentration much more extensively—perhaps to nitrous acid, nitrogen, or even to ammonia.

This may suffice to show the details of the plan. I believe that any such plan built on the fundamental principle of arranging the material into a progressive study of reactions will get results which are of prime importance, and which under any other plan are obtainable only with difficulty.

It may be said against this plan that it makes the study of chemistry too formal for secondary school work. A discussion on this point would probably take me far beyond the limits of this paper, and so I must content myself with expressing my own view in this connection. I believe in teaching chemistry just as rigorously as mathematics. While it is true that a great deal of the value of the course depends upon its information feature, yet it appears to me that primarily the attention should be fixed upon the training feature. It is probably no unjust criticism to say that at present high school instruction is particularly deficient in developing strength in the student of chemistry. Furthermore, the information feature without rigorous training may have a very questionable value—it will certainly improve when the training feature is emphasized. Of course, the latter must never be allowed to crowd out the former.

This outline (and perhaps any outline based upon the fundamental principle under consideration) destroys two particular features of the arrangement now in use; first, the placing of all the non-metals ahead of the metals, and, second, the grouping of the elements according to the periodic system. These features of the present arrangement may be of some service in arranging the material in book form, but it can scarce be claimed

that they have any particular pedagogic basis. It is true that the periodic system groups the elements in accordance with their properties, but it is well known that the properties considered for this purpose are frequently the properties not commonly met with, and that the common properties would often place the elements in entirely different groups. Furthermore, in an introduction we are not concerned with the conveying of certain information or facts concerning elements and compounds as much as we are concerned with the preparation of the student's mind to receive such information later on and to enable him to comprehend such information fully.

SIMPLE EXPERIMENTS IN CHEMISTRY FOR USE IN ELEMENTARY SCHOOLS.

By George W. Fowler,

Syracuse Central High School.

The following fifteen experiments are suggestive as to what may be accomplished in the teaching of chemistry in elementary schools. The experiments may be used as demonstrations by the teacher in rural schools, in the seventh and eighth grades of grammar schools, or will adapt themselves for practical use in the hands of first year pupils in high schools. Under such conditions expensive apparatus is not practicable, since the teacher's time and knowledge of chemistry is often necessarily limited. These limitations have been kept in mind in outlining the work.

Any boy can make the necessary apparatus and provide the materials, the total cost of which need not exceed fifty cents.

The aim of the exercises is to show the composition of air and water, the nature of their composing elements, and to illustrate the essential plant foods.

I have taken as a basis in assembling the apparatus, Bulletin 195 of the United States Department of Agriculture. A simple inductive method has been used to obtain desired conclusions.

EXERCISE I.

Experiment I—Combustion.

Twist a piece of wire around a lighted candle and lower it into a tumbler. Cover the mouth of the tumbler with a piece of card-board or a glass plate.

1. What happens to the candle? Why?
2. What is necessary for burning?

SUMMARY: The burning of a substance is combustion. The air supports combustion.

EXERCISE II.—OXYGEN.

EXPERIMENT 2. PREPARATION.

Put a little powdered chlorate of potash and sand, equal parts, in a dish and stir until they are well mixed.

Twist one end of a piece of wire, about 6 inches long, around a thimble. Bend a loop in the other end for a handle. Fill the thimble about two thirds full of the mixture. Using the loop as a handle, hold the thimble in the alcohol flame. The mixture will soon begin to "boil," this is caused by the bubbles of a gas, oxygen, bursting through.

EXPERIMENT 3. TESTS.

After the mixture is boiling, light a toothpick and blow it out, leaving a glowing end. Put this glowing end in the thimble just above, or even into, the "boiling" mixture.

1. What happens to the spark on the end of the toothpick? This is a test for oxygen.

Bend a piece of wire into a loop around the point of a lead pencil. Heat the wire, dip it into some sulphur, and hold it just above the boiling mixture as in the case of the glowing toothpick.

2. What change do you observe in the burning sulphur?
3. How, in general, does oxygen affect a burning substance?

SUMMARY: Oxygen is a gas and may be prepared by heating chlorate of potash and sand.

Combustion is more rapid in oxygen than in air.

It is the oxygen in the air that causes it to support combustion.

When substances burn in oxygen they combine with it. This is called oxidation.

(Suggestion: The thimble may be cleaned by filling it with water and boiling it in the alcohol flame.)

EXERCISE III.—CARBON DIOXID.

EXPERIMENT 4. PREPARATION.

Put a teaspoonful of soda in a small olive bottle or other wide mouth bottle, and cover to a depth of about one half inch with vinegar. The bubbles that are given off are carbon dioxid gas, commonly called "carbonic acid gas." This gas is heavier than air, and may be poured like water.

EXPERIMENT 5. TESTS.

After the vinegar has been on the soda about a minute, plunge a lighted match into the bottle.

1. Does carbon dioxid support combustion? Compare with oxygen in this respect.

Into a tumbler containing a little lime-water pour the gas out of the olive bottle, being careful not to tip the bottle far enough to allow the vinegar to run out. While pouring, put the neck of the bottle well into the tumbler. Remove the bottle, cover the tumbler with the hand, and shake.

2. Describe the effect of carbon dioxid upon lime-water. This is a test for the gas.

By means of a straw, blow into some lime-water in a "pill" bottle.

3. State the effect of your breath upon lime-water.

4. What gas in your breath caused the change?

Drop a burning match into an empty bottle. After the match has gone out, pour a little lime-water into the bottle, cover with the hand, and shake. Result?

5. What gas is a result of combustion?

Set a saucer containing lime-water on the floor. After a while there will be a white coating over the lime-water.

6. What substance does this show to be present in the air?

SUMMARY: Carbon dioxid may be prepared by adding vinegar to baking soda. It is a heavy gas, and turns lime-water milky.

Carbon dioxid is a product of respiration and combustion. It is found in the air.

EXERCISE IV.—NITROGEN.

EXPERIMENT 6. PREPARATION.

Lay a glass plate flat in the bottom of a small basin. Pour a tumbler full of lime-water into the basin. Soak a bit of sponge in alcohol; place the sponge on a flat cork, and float the sponge and cork on the lime-water. Apply a flame to the sponge and, while burning, quickly lower a tumbler over the flame, resting the tumbler on the glass plate. The sponge will continue to burn until all of the oxygen is removed from the air inclosed in the tumbler.

1. Why does the lime-water rise in the tumbler?

Hold the basin firmly with one hand and with the other move the tumbler back and forth on the glass plate, thus causing the lime-water to "slop" around in the tumbler.

2. What change do you observe in the lime-water?

3. What is a product of the combustion of alcohol?

Carbon dioxid is absorbed by the lime-water, and nitrogen is left in the tumbler.

EXPERIMENT 7. TESTS.

1. Has the gas nitrogen any color?

Keeping the tumbler *tightly covered* with the glass plate, remove the tumbler from the basin and set it upright on the desk. First light a match, then draw the glass plate a little to one side and quickly thrust the lighted match into the tumbler.

2. Does nitrogen support combustion?

3. Compare with oxygen and carbon dioxid in this respect.

SUMMARY: Nitrogen is a colorless gas, and may be prepared from air by burning out the oxygen.

Nitrogen does not support combustion.

The air is a mixture—chiefly of nitrogen, oxygen, carbon dioxid, and water vapor—the presence of the latter being shown by dew, frost, and the "sweating" of a pitcher of cold water.

The nitrogen in the air serves to dilute it; otherwise combustion would be too rapid. Coal, wood, etc., would burn up rapidly, and fires once started could be extinguished with difficulty.

Air is about four fifths nitrogen.

Oxygen in air causes it to support combustion. Air is about one fifth oxygen.

Carbon dioxid is present in small amounts and is a plant food.

EXERCISE V.—HYDROGEN.

Experiment 8. Preparation.

Into an olive bottle put about a tablespoonful of zinc cut into pieces not larger than one half inch square. Cover to the depth of an inch with water. Into the water pour a "pill" bottle full of sulphuric acid.

Observe Precaution on Apparatus Sheet.

Bubbles of hydrogen will be seen to rise from the zinc.

Experiment 9. Tests.

After two or three minutes bring a lighted match near the mouth of the bottle.

1. Is there an explosion?
2. Does the hydrogen burn at the mouth of the bottle?

If so, hold a cold glass plate over the flame. Note the vapor that condenses on the glass plate and on the inside of the bottle. This is water.

From Exercise I we learned that when a substance burns in air or oxygen it combines or unites with the oxygen.

3. Of what two gases is water composed?

Summary: Hydrogen is a gas which explodes and burns when mixed with air. The product of the combustion is water.

Water is composed of hydrogen and oxygen.

Hydrogen burns; substances burn brightly in oxygen; and yet water "puts out" a fire.

EXERCISE VI.—CARBON.

Experiment 10. Examples of Carbon.

Examine a piece of clean coal. Give its color. Compare its hardness with that of charcoal.

Examine the "lead" in a pencil. Give its color. Draw each of the coal, charcoal, and pencil across a piece of paper. Which makes the best mark? Which the poorest?

Wrap a wire around a piece of charcoal and hold it in the alcohol flame until it glows. Thrust the glowing charcoal into an olive bottle and allow it to remain until it stops glowing. Remove the charcoal, pour lime-water into the bottle, cover with the hand, and shake. Result? What is the product of burning carbon?

Summary: Coal, charcoal, and graphite—the latter is the correct name for the "lead" in pencils—are all forms, more or less pure, of carbon. Wood is largely carbon, and when heated it chars, forming charcoal.

The diamond is the purest form of carbon and is the hardest known substance.

When carbon burns it unites with oxygen, forming carbon dioxid. (See exercise III.)

EXERCISE VII.—POTASH.

EXPERIMENT 11. PREPARATION.

Into a pan, put about three quarts of well-sifted wood ashes and cover with water to the depth of about one inch. Allow it to stand for twenty-four hours, stirring occasionally. Carefully pour off the liquid into a dish. Care should be taken to get as little sediment as possible. When the liquid has settled, again pour off into a second dish, leaving the sediment behind. Continue this operation until a clear, yellowish liquid free from sediment is obtained.

Place the liquid in a clean basin and evaporate on a stove or over a flame until all of the liquid has disappeared. Potash remains in the dish.

Transfer the potash to a wide mouth bottle (a vaseline bottle is good), label, and preserve.

EXPERIMENT 12. TESTS.

Moisten the fingers and rub a little potash between them. How does it feel?

SUMMARY: Potash may be prepared by "leaching" wood ashes and evaporating the resulting solution.

It is an essential plant food.

Potash is used extensively in the making of soap.

EXERCISE VIII.—PHOSPHORIC ACID.

EXPERIMENT 13. PREPARATION.

Place a bone in the fire of a stove or furnace and allow it to burn as much as it will. There remains from the heating a white, brittle substance—bone phosphate.

Grind finely, with a stick or stone, a few small pieces of the burnt bone. Place the bone-dust in a small saucer, cover to the depth of about one half inch with water, and add about three drops of sulphuric acid. (OBSERVE PRECAUTION WHEN HANDLING THIS ACID.) Stir the contents of the saucer and allow to settle. The liquid on top contains the dissolved phosphoric acid.

Pour off this liquid into a small bottle, label, and preserve.

SUMMARY: Phosphoric acid may be prepared from burnt bone by heating it with water and sulphuric acid.

Phosphoric acid is a plant food, and, together with nitrogen and potash, makes up the three essential foods for plants.

EXERCISE IX.—LIME.

EXPERIMENT 14. PREPARATION.

A piece of limestone is needed for this experiment. To recognize limestone, place one drop of sulphuric acid on a stone. If limestone, bubbles will appear. Other kinds of rocks will not bubble when treated in this way.

Place a piece of limestone in a stove, or, better still, in a furnace, where a steady and high temperature is assured. Leave the stone undisturbed for about twelve hours; then carefully remove it. The product is lime.

EXPERIMENT 15. TESTS.

Break up into small pieces some of the burnt limestone or lime, and put them into a dish. Add water and stir. Allow to settle if necessary, then pour off the clear liquid on top into a small bottle.

Using a straw, blow your breath through the water. Result?

1. Name the solution into which you breathed.
2. What gas in your breath caused the change?

SUMMARY: Lime is made by burning limestone; this consists in driving off carbon dioxid gas.

Lime added to water makes lime-water. Lime is slaked in this way.

Lime is used for building purposes, and, like phosphoric acid and potash, is a plant food, though not so essential.

MATERIALS.

1 alcohol lamp, made out of an ink bottle, cork, empty cartridge, and string, as follows: Drive the cartridge shell through the cork, file off the closed end and punch out the cork inside the shell. Twist a string into a wick and draw it through the shell. The shell and wick should project above the cork about one half inch. Fill the bottle about one half full of alcohol. Place a thimble over the wick to prevent loss of alcohol by evaporation.

1 pound of lime in a tightly corked wide-mouthed bottle.

1 quart of limewater, made by putting a handful of lime in a bottle. Fill with water, shake, and allow to stand.

1 pint bottle of alcohol, wood, or denatured.

1 small bottle, to pour the clear limewater into.

1 small bottle of vinegar.

1 small bottle (wide-mouthed) of baking soda.

1 small bottle of chlorate of potash.

1 small bottle of sulphuric acid.

2 feet of broom wire.

Several splinters of wood (tooth picks).

1 thimble.

1 glass tumbler.

1 flat cork.

A bit of sponge.

1 candle.

1 glass plate 3½″ square made from a broken window pane.

Sand.

Sulphur (flowers.)

Several straws about six inches in length with no joints.

Panful of wood ashes.

Bones.

Limestone.

Pint basin.

2 or 3 olive bottles.

2 or 3 "pill" bottles.

All materials in bottles should be labeled.

Alcohol and sulphuric acid are poisons and as such should be labeled.

CAUTION: When using sulphuric acid great care should be taken not to spill any on the hands, clothing, or desk; in case some is spilled, wash immediately with plenty of water and if possible pour on some ammonia. The burns from sulphuric acid are *painful* and *serious*.

Materials which cannot be obtained from the home may be purchased at a drug store.

THE PURPOSE AND ORGANIZATION OF THE TEACHING OF CHEMISTRY IN THE SECONDARY SCHOOLS.

(Symposium continued from May issue.)

IV. BY B. W. PEET,

State Normal College, Ypsilanti, Mich.

When one is asked to answer what to teach and how to teach any particular subject, the answer must be in the first place only a personal opinion, and if this opinion is to meet general favor it must please the general public. Perhaps one might say it was setting a low standard to endeavor only to please the public, and that it would be much wiser to teach with the view of meeting high aims in education. When one studies the changes that have taken place in all our educational institutions in the past generation, it is at once evident that the public determines what shall be the nature of education.

Then we are confronted with the question, "What is the aim of education?" What constitutes a liberal education is largely determined by the opinions of our best scholars or leading educators, and opinions vary from decade to decade.

Spencer says, "Men dress their children's minds as they do their bodies, in the prevailing fashion." The present status of opinion in all branches of education and even in religion is toward things practical. We will always teach with a view to general culture, but we now believe that the best kind of culture is obtainable from the study of those things which have a bearing on the actual life of the pupil. We have come to measure the value of human effort in terms of the immediate practical results that are likely to accrue from it. "We have an indistinct realization that nothing is of real worth unless it can be directly connected with some result of conspicuous benefit to mankind, individually or collectively, economically or socially."[1]

[1]Arthur Dewing, SCHOOL SCIENCE AND MATHEMATICS, October, 1908.

Education should aim to develop a strong mind and to fit one for more complete living and more effective social service. Education represents mental power, and to gain this due regard must be given to every valuable mental function. Observation, perception, reason, imagination, and memory must be considered. Means of leading to better processes of thinking must be cultivated, and an endeavor must be made to teach the student to think and do something himself and not merely to remember other people's thoughts. How, then, shall we teach chemistry to meet these ends?

In the first place I want to emphasize that in order that chemistry meet these ends, it should be taught in the last year of the regular high school course, immediately following physics. That is certainly the logical order, for every chemical experiment involves a knowledge of physical phenomena, and many of our best educators tell us that it requires a more mature mind to grasp the theoretical reasoning which is so essential in a good course in chemistry.

Many of the best teachers of physics, both in our universities and high schools, now advocate that little time be given to *accurate* measurements and advocate more work in practical physics or that which refers more directly to the experiences of everyday life. When high school teachers of physics learn better than to teach college physics in high schools and teach the kind of physics that is practical and interesting and requires only a mathematical knowledge of algebra and elementary geometry, the subject can well be taught in the eleventh grade. A prominent physics teacher tells me that he asks that the student know arithmetic and elementary algebra only.

I doubt the possibility of teaching chemistry that is really worth while without a knowledge of elementary physics. Every chemical action involves a physical process. The interpretation of the simplest chemical change depends upon a knowledge of physics. For example, in the experiment of the heating of iron and sulphur to form iron sulphide, how do we know that it is a chemical change? We learn that chemical change is the formation of a new substance with entirely different properties. So we must know the physical properties of the iron and the sulphur before the experiment, and of the iron sulphide after the experiment.

It would be folly to study Avogadro's hypothesis and the gas laws without some knowledge of the kinetic theory of gases, or to study ionization without some knowledge of electricity. "It is indeed an invariable characteristic of every chemical phenomenon that our information is all derived from the physical study of materials."[2] The chemistry that is commonly taught in our high schools is justly criticised in that it does not develop accurate observation and mental power, for it is often taught without any knowledge of physics and with no particular aim in view other than to learn a few interesting but unrelated facts.

To teach any branch well, the teacher must be enthusiastic and full of his subject. Enthusiasm creates interest. If you cannot interest the student he will make slow progress. In any event the teacher should have definite ideals. We teach with a view to general culture, but must realize that the best kind of culture is obtainable from the study of those things which have a bearing on the actual life of the pupil. So in outlining a course of study we should have in mind our aim in education and endeavor to present the subject in such a way as to develop mental power and fit one for more complete living.

In the first place the student must learn a number of facts. These are necessary for the proper understanding of the subject, but the mere learning of the facts is of little educational value in the highest sense. It is the understanding of the relations between these facts and the drawing of conclusions from them that gives mental power. It is a common error in science teaching to ask students to learn a lot of facts without associating them. In chemistry there is a splendid opportunity to compare or reason by analogy. After the student has studied a few elements, compare them. How are they alike? How do they differ? After any group of elements, like the chlorine family, has been studied, make careful comparisons of methods of preparing the elements and their compounds. Our best texts do this, but a live teacher will add to the suggestions in the book and keep up the method all through the teaching of the subject. "Education should lead to better processes of thinking, and thinking consists in the perception of relations—resemblance."[3] So chemistry offers an unusual opportunity to put in practice the principles of education.

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[2]Alexander Smith's College Chemistry.

[3]Nathan Harvey, SCHOOL SCIENCE AND MATHEMATICS.

I see no objection to the so-called historico-systematic method as followed by most of the best texts now on the market, unless it be too much ground is covered. There is great value in a well ordered outline knowledge of the whole science, for it gives a better understanding of its parts, but we are in danger of missing our aim in the endeavor to give a broad view of the subject and not fix in mind the fundamental principles of chemistry so essential to its proper understanding. A common error in teaching is to cover a certain amount of ground regardless of whether the class comprehends the subject matter covered.

President Ira Remsen says, "An important defect in the present teaching of chemistry in colleges is the absence of repetition. There are too many fleeting impressions." He might well have applied this to the teaching of chemistry in high schools. Less ground should be covered and more repetition, more review should be required. The drill element in language and mathematics is lacking in science teaching and yet there is plenty of opportunity for using it.

Another defect in chemistry teaching is there is not enough affiliation of class room work with the laboratory work. We should ever keep in mind that chemistry is an experimental science. In the beginning the teacher should perform the same experiments in the recitation room that the student is to perform afterwards in the laboratory.

Many definitions in modern texts are faulty or are difficult for the average student to comprehend because they are theoretical definitions rather than experimental. The experimental method of expression as used in Alexander Smith's College Chemistry should be used more in our high school texts. For example, the definition commonly given for valence is the capacity or the property an element has for holding another element in combination. How much more definite is the following definition: "The valence of an element is the number of equivalent weights contained in its atomic weight." The student's knowledge of equivalent weight is gained by actual experiment and he also learns how the atomic weight has been determined experimentally.

The working of problems is an exercise too often neglected. Problem working emphasizes the quantitative character of chemical change, develops reasoning, memory and independent thought. Problems are excellent for review work. The teacher

can very profitably make them up, based upon the laboratory work or the student's experience in daily life.

One of the chief defects in laboratory instruction is lack of personal supervision. It is so easy for the teacher to give the students a laboratory manual and let them work without further directions. A beginner, especially, needs the personal contact with the teacher. The teacher should be in the laboratory during the laboratory period, passing from desk to desk, asking a question now and then to keep the pupils thinking as they work, suggesting better ways of manipulation, but at the same time letting them work things out for themselves. This is the only way to avoid mechanical work and to teach pupils to reason and think more as they work. Laboratory work properly taught is a most valuable means of instruction. Professor Alexander Smith calls attention to its value for giving first-hand knowledge, for holding interest and attention and for securing clear and pregnant expression.

To be of the most value, the laboratory notes should be written up in the laboratory and as soon as each experiment is completed. The student should learn from the very start to express as accurately as possible what he sees and draw conclusions while the experiment is fresh in mind. This may sacrifice neat notebooks at the beginning, but there is no reason why in time the student should not acquire neatness as well as accuracy.

The successful presentation of any subject, however, depends more on the enthusiasm of the teacher than anything else. Our most successful teachers are full of their subject, enthusiastic and hard working. To develop properly a student's mind you must hold his interest and interest is begotten by enthusiasm. However, a teacher may be enthusiastic and full of his subject and be unable to keep up the interest of his students, because he endeavors to teach things beyond their comprehension. This is one of the mistakes made in physics teaching. Too much quantitative work or accurate measurement will cause the students to lose interest.

So then the great problem of every successful teacher is to present his subject so as to hold the interest of his students and at the same time give them a course that is worth while and in line with the highest principles of education.

V. BY PRESIDENT FRANCIS P. VENABLE.

Chapel Hill, N. C.

I wish to say at the outset that I have had some experience in teaching science in a high school and twenty-odd years of teaching chemistry in a university. My experience in both capacities has led me to the conviction that it is a serious mistake to attempt to include the study of the science of chemistry in the ordinary high school course. I am inclined to think this is true of any science, but of the others I do not feel that I am so well fitted to judge.

In saying this I am referring to the science as such and not to an introduction to it or an elementary smattering of it. The latter I believe is of very little service to anyone.

I have examined a number of text-books on chemistry intended for school use and to my mind they all have such serious defects that they are of slight educational service. It is true that I was unwise enough to write an approving letter of one many years ago but I have duly repented of that.

The difficulty consists in making choice as to how much and what shall be omitted. If the subject is to be treated as a science, a great many facts must be given so that the student may have a comprehensive grasp of the subject. It is idle to count upon an intelligent insight into the science without a survey of the whole field and the mastering of many facts. For this there is no time in the ordinary high school course. It belongs to the college and there only can such comprehensive treatment be given.

As soon as the process of elimination begins, the writer of the text-book is hard put to it in his enforced choice between facts and definitions, laws, theories, etc. He cannot well omit the latter and call it a science. He therefore culls his facts, leaving so few that the laws are not sufficiently impressed as to become apparent to the student and hence of real value to him as a part of his mental makeup. These definitions and laws become a mere matter of memory. They are held imperfectly and lead to a kind of mental indigestion instead of making clear the ordinary processes of nature in one's environment. I have seen some text-books which were about as intelligible and helpful for a proper understanding of things as an abridged dictionary.

Some seem to think that a greater educational value lies in the

experimental side, in proving the facts in the laboratory. There is really very little in this. For one fact which a beginner can prove there are hundreds quite beyond his manipulative skill, his technical knowledge, and the time and apparatus at his disposal. Then, too, he really understands little of what is going on under his hands and before his eyes. The whole thing is too often a bit of scientific trifling, amusing the pupil, perhaps, but giving him false notions as to what he has attained and how far he has journeyed in the exacting field of his science. I recall one widely used school chemistry which gives as the first experiment a ridiculously insufficient one as to how to prove that a certain substance is an element—one of the most difficult of problems which has caused the downfall of many a highly trained chemist.

Again, I object to the teaching of the science of chemistry in the schools because the average youngster under eighteen years of age is too immature to grasp it. I know the difficulties in the way of teaching it to college students of nineteen or twenty and the large proportion of failures there. It is too often only a parrot-like acquisition even on their part and of no earthly value to the thinking man inside.

When it comes to the practical test of the class room, I frankly prefer to attempt to teach the college student who is taking up the study of chemistry for the first time to instructing one who has been put through the ordinary high school course, and my experience covers many students trained in schools in a number of different states. The one who has had the high school course, in the first place, has had the novelty of the study worn off. Again, he has formed wrong conceptions which must be unlearned and too often he has been so confused by his foretaste as to conceive more or less of a dislike to the whole subject.

The high school course cannot be the equivalent of the college course and I cannot give my consent to accepting it as a substitute for it. While it may be accepted among the entrance requirements of the college, I would greatly rather not have it offered and the work must be repeated properly for there is no building to be done on such a foundation.

Someone has very foolishly said that the high school is the people's college and this has led to incorporating into the school curriculum some of the things that belong to the college, to the great detriment of the school. Among these I would include the sciences.

What I have written refers to the sciences as such. I advocate strongly the teaching of introductory courses in the sciences. They have a splendid function in mental training whether the pupil is to go on to college or to go straight from the school into his lifework. These introductory courses should deal with everyday facts and phenomena. They may involve simple reasoning and explanation. They should aim to cultivate the powers of observation and accuracy of description. They should have as few definitions as possible and avoid laws and theories. In chemistry, for instance, elements and compounds, atoms and molecules, affinity and the like are quite unnecessary conceptions and may well be left to a later day, or left out altogether if that be a necessity, for chemists are still defining, attacking or defending even these fundamental concepts of their science.

Tin has been discovered in Zululand in the neighborhood of the Umfuli.

The Transvaal government has decided that no further diggers' rights will be issued on the Appingendam "tin" farm.

Some coals liberate gas during storage, of a composition similar to that of natural gas, and some coals rapidly absorb oxygen from the air during storage without forming CO_2.

The nature of the volatile products distilled from several coals at low temperatures in the early stages of heating vary in different coals in accordance with their smoke-producing tendencies.

During drying in air at 105° C., some coals lose appreciable amounts of CO_2, and most coals take up oxygen to a considerable extent, but none of those tested show any considerable formation of combustible gases.

Coal is almost the only British commodity imported into Madagascar, but the fact that the amount imported has trebled itself in the last three years shows that there should be some opening for machinery in spite of the high customs duties.

The problems of the occurrence, the volume, the direction and rate of percolation, and the accessibility of the ground waters in any region are intimately related to the rock masses, their position, character and attitude, and these are problems of geology. The study of ground waters, then, is in many of its phases an application of geologic principles and can not be carried out with thoroughness or success unless those elements of the geology which have a bearing on the problems are studied at the same time.

THE DUODECIMAL SYSTEM OF NOTATION.

By L. H. Vincent,

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It is often remarked that the general adoption of the metric system of weights and measures would facilitate calculation because the metric system is based upon the decimal scale of notation. It perhaps has not occurred to the ordinary mind that the decimal scale itself is an arbitrary arrangement that was started because our ancestors counted on their fingers, and after counting to ten they could go no farther without starting over again. Had they been able to see two points beyond the tips of their fingers they would have given us a scale of notation that would have been more convenient than the decimal scale.

What has given to the numbers ten, one hundred, and one thousand their prominence as stations in the scale of notation? Simply the fact that our ancestors when they had counted to ten drove a stake there and hallowed the spot; and succeeding generations have supposed that ten held its commission of nobility from the eternal nature of things instead of from chance. The ten characters that we use in writing numbers are called digits, which is also the name for our fingers.

If you were to build a railroad you would select for stations the points that afford the best natural facilities. Now what natural advantage has the number ten over any other number to fit it for the position it holds? If you are liberal minded enough and sufficiently free from dogmatism that the number ten is not deified in your mind you may admit that it has no special advantages, but may perhaps contend that its advantages are at least equal to any other. You may esteem every number alike and ask how any number can possess properties that fit it any better for a station of nobility than another.

Do numbers have individual characters? Yes, each has a distinct personality. Some are related to each other and others have nothing in common with each other. The traits of character and relations that I refer to are inherent characteristics that could not be changed no matter what system of notation was in vogue. In the first place all numbers belong to two classes, odd and even. Now no odd number is suited for the position held by ten. Its very nature is against it; for then we could have no half way station. We all know how easy it is to

count by fives or recite the fives in the multiplication table, or perform numerous short methods where the number five is involved. That is not due to any inherent quality of the number five but to the fact that it is a half way station. It is the royal favor conferred upon the number five by its relative ten whom our ancestors crowned in the ages of barbarism and to whom we still pay our allegiance. I am glad that one number enjoys that special favor. It makes easy calculations. I only regret that other numbers cannot come in for royal favor also. But I suppose that if our ancestors had possessed but one arm and an odd number of digits upon it, we would now be burdened with a disjointed system of notation based upon an odd number and we would have thought it the only system and clung to it as faithfully and as blindly as we now do to the decimal system.

Another classification of numbers according to their inherent nature is into prime and composite numbers. A prime number would never do as a basis for a scale of notation for the reason that it has no relatives (factors) on which to bestow its royal patronage. We have seen how nice it is that ten has bestowed its royal favor on its factors two and five but there its patronage ends. It shows no such favors to any other. We can count by twos or by fives and fetch up with a full stop at every decimal station; but when we try three we find ourselves on a through train that runs past two stations out of every three. Try four and we run past every other station. Number four comes in for a little more favor than three because it is indirectly related to his majesty, ten. They have a common relative in the number two. But number three has an extremely peculiar schedule. It stops, perforce, at the royal stations thirty, sixty, and ninety, but it flies past one hundred with a full head of steam. It snubs one thousand as if it were not even a flag station. But it pays dearly for its hostility to the royal family. Its relatives six and nine share its fate. Nine is treated even worse than three perhaps because it is three threes. Six has a common relative with ten in the number two, but his royal majesty cannot overlook its kinship with the hated three and therefore does not extend to it the favors enjoyed by four. Of course four is more closely related to two than six is because it is the product of two twos while six is a cross between a two and a three. Four is a thoroughbred, six is a mongrel and has therefore lost its caste, for no kin of that hated three can expect any royal favors. Three and ten are absolutely and eternally inimical to each other.

Even in the world of fractions the relatives of three, one-third, one-sixth, and one-ninth, share its fate and they and their multiples suffer from royal disfavor. Did you ever try to reduce one of them to a decimal fraction? You can't do it and get rid of your fraction.

In this everlasting hostility between ten and three I am inclined to take the part of the number three. Not that I blame ten, for it is easier for a camel to go through the eye of a needle than for ten to change its nature. Even composite numbers if they have no common prime factors are prime to each other and are then uncongenial spirits. Their dispositions are inimical to each other. Of course numbers must have their enemies just the same as people since they each have their peculiar dispositions; and no matter what number was used as a basis of notation it would have its inimicals. But it is a matter for regret that a number so fundamental in its relation to nature and nature's forms as the number three is should be out of harmony with the system of notation, like a prominent statesman out of harmony with the administration.

Prime numbers are the independent citizens of the numerical world; they have nothing to do with any but their own multiples and unity. Of course every number is in harmony with unity. Unity signifies perfection or completeness and gives the name to the universe. Nothing can be out of harmony with unity. To it and from it proceed all methods of calculation. Unity is the only deity in the realm of numbers. Of it are all numbers created in its likeness. All numbers are but repetitions of unity. The number one is both an odd number and a prime number. It is chief of the prime numbers and all the other prime numbers owe their distinct individuality to their relation to unity.

Composite numbers are the products of prime numbers and, true to the principles of heredity, they inherit all the traits of their prime factors. The number three being composed of three units, is divisible into three equal integral parts. That is its distinct characteristic which it imparts to all of its multiples. Therefore every composite number having three as a factor is capable of division into three equal integral parts. And so it is with all prime numbers; they each derive their individual character from unity the common father of all, and convey it to their offspring.

Now as the most successful governor of a state is one who

can harmonize the greatest number of factions, or the one with the most friends and fewest enemies; so the most suitable number for the basis of a scale of notation is the one in harmony with the greatest number of factors; particularly those factors that are fundamental in their relation to nature. I claim that advantage for the number twelve over the number ten as a basis for a scale of notation. In other words, the duodecimal scale would give us a more convenient system for the reason that the number twelve and its multiples are capable of division into a greater number of integral aliquot parts. Although custom has established a station at ten, yet more trains stop at twelve, for whether you count by twos, threes, fours, or sixes, you are sure to stop at twelve. Custom can't change nature. Twelve has a wider range of patronage than ten, and fewer inimicals; more friends and less enemies.

By the duodecimal scale of notation I mean a system in which the value of the unit of each order shall be twelve times the value of the unit of the next lower order. As in the decimal scale we have ten units in a ten, ten tens in a hundred, etc., so in the duodecimal scale we would have twelve units in a twelve, twelve twelves in a gross, etc. The value of the orders of units would increase from right to left at the ratio of twelve.

This scale may seem hard and confusing, but that is only because we have become accustomed to think in the decimal scale. It would be easier than the decimal scale if we had only got started that way. But now if a number were written in the duodecimal scale we would have to translate it into the decimal scale before we would have any conception of its value. In fact to adopt the duodecimal scale into general use would be such a radical change and would necessitate such overwhelming changes in our very methods of thought that I am not brave enough (perhaps I should say foolish enough) to advocate it seriously as a reform. Yet I would like to call attention to its advantages. I am satisfied that in adopting the decimal scale we got started wrong; but we are such creatures of habit that to get out of the rut we are in is the next thing to impossible.

In order to use the duodecimal system it would be necessary to have two more characters or digits to represent ten and eleven. Suppose we were to adopt the system and should use X to represent ten and Y to represent eleven. Then 10 would be twelve (i. e., one twelve and 0 units). What we now call

thirteen would be represented by 11 (1 twelve and 1 unit). We would call it onedeen. The next could be twodeen and so on to tendeen and elevendeen. Then would come two twelves which we might call duoty since two tens are now called twenty. Then would come duoty-one, etc. In due order we could have terty, quarty, quinty, sexty, septy, octy, nonty, tenty, eleventy, and one gross. I know that sounds silly, but couldn't we say one-gross quinty-six (written 156) as easily as we could say one hundred fifty-six? Translated into the decimal scale that number would be:

One-gross (twelve twelves)	144
Quinty (five twelves)	60
Six units	6
Total	210

Foolishness! did you say? Well perhaps, but let us go a little farther and see some of the advantages. Six would enjoy all the privileges as a half way station now conferred upon five. Its multiples would all end in 6 or 0. We would have the conveniences of quarter way stations and even third way stations. All multiples of four would end in 4, 8, or 0, and all multiples of three would end in 3, 6, 9, or 0. Under the decimal system such uniformity is only enjoyed by two and five. Two would enjoy privileges under the duodecimal system the same as it does under the decimal system and all its multiples would end in 2, 4, 6, 8, X, or 0. Only the number five would lose its caste and be expelled from court. In its place we would have three, four, and six as direct favorites and eight and nine would come in for indirect favors. Seven and eleven would not be favorites but neither are they under the decimal system, so we would lose nothing by their enmity. Ten of course would lose by its dethronement but twelve would gain all that ten would lose.

In the realm of fractions the most natural division of any unit of measure is into halves. The next most natural division is quarters. Then it comes natural to us to divide each quarter into eighths. Take the foot rule for instance and see how each inch is divided into halves, quarters, eighths, and sixteenths. Some are divided into quarters and then each quarter is cut into three pieces giving us twelfths. In my opinion the latter arrangement is better because we can then measure thirds or sixths of an inch, while with a rule divided into sixteenths we could

not measure a third of an inch without guessing a little. Such a rule would be constructed on the duodecimal scale. Why is it convenient to divide a foot into twelve inches? Because it can then be divided into halves, thirds, fourths, or sixths with integral results. But we cannot divide it into fifths and we would seldom want to do so if we were not burdened by the decimal system, because a fifth is an unnatural division. Why do we have half dollars and quarter dollars? Because they are natural divisions of the unit. We could have a third dollar coin if the number three were not out of harmony with the system. Five is in harmony with the system yet we have no fifth dollar coin because we don't want any. We have had a twenty cent coin which in fact was a fifth of a dollar but it was not called such by name, while the 25 cent piece and 50 cent piece are specifically called quarter dollar and half dollar respectively. Why did we once have a two and one-half dollar coin? Because of the natural desire for a quarter eagle. This shows that halves and quarters are the most fundamental divisions of the unit. Thirds are not quite so fundamental as quarters, but they are more fundamental than fifths. Three outranks five; it is nearer unity and closer to nature. Four has more favors than three because it is a composite relative of two, but five is a still more remote prime number and it is only due to administrative nepotism that five is blessed and three is accursed; while three in its inherent nature merits more favors than five.

Look at the face of your watch and see if you could divide it into a more convenient number of spaces than twelve. How else could it be resolved into halves, quarters, or thirds? If it were divided into ten spaces for hours when would it be quarter past six? Our measure of time as well as the foot rule is out of joint with the decimal system but it is in harmony with the nature of all measures. Even in France, the home of the metric system, they use the same measure of time as we; their clocks and watches are made like ours and they figure angles and circles in degrees the same as we do. By dividing the hour into sixty minutes we accommodate even the factor five. No other division would give so many facilities. For this reason there are twenty-four hours in a day (twelve for the day and twelve for the night), and twelve months in the year, twelve signs in the zodiac and twelve signs in a circle.

Let us see how important a factor three is in its relation to

space. Draw a circle and inscribe the hexagon; then from the alternate corners of the hexagon, or points of division, of the circle, draw three radii. Now look at your figure and you will find yourself looking directly at the corner of a cube. A cube has three dimensions, six faces, eight corners, and twelve edges. The number five seems to have no part in the plan of construction. Even to find the area of a pentagon we would divide it into triangles, and we find the cubic contents of a pyramid or cone by multiplying the area of the base by one-third of the altitude.

Equilateral triangles, squares, and hexagons match perfectly when grouped together. Octagons fit together leaving small squares; but pentagons do not match. Who has not observed the hexagonal shaped columnar rocks in geological formations, or the shape of the cells in a honeycomb?

Divide a circle into quarters and you have four right angles at the center. The right angle is the fundamental angle. What would the carpenter or the mason do without his square? The simplest plane figure is the square or rectangle which has four right angles and two dimensions. This shows the fundamental nature of two and four. There are four cardinal points to the compass. Wagons have four wheels; a fifth would be a superfluity. Yet we have vehicles with three wheels, and some with two. Animals have two legs or four. Five is represented in most animals by the number of digits on each limb; yet with many of the lower animals the fifth toe has degenerated into a useless appendage. Fowls usually have four toes on each foot. We have five senses but we know not if that completes the lot; indeed there is so much that is a mystery to us that it would seem that they do not. Because we are blessed with more faculties than the lower animals is not proof that we have a full complement.

Thus it is seen that ten is the real hybrid in the numerical world inheriting its even nature from its factor two and its eccentricities from the factor five. Ten is the usurper of honors it does not merit. The truly royal blooded numbers are the multiples of two and three.

Now let us see how the decimal system treats the fractional world. We have already seen that the most fundamental fractions are halves, quarters, and thirds. Now of these the half is the only one that can be expressed by one decimal place.

Fourths require two decimal places and eighths three, and so on every time the fraction is bisected another decimal place must be added. Thirds cannot be expressed decimally at all.

How would it be with duodecimals? One-half would be .6 (six twelfths), one-fourth would be .3 (three twelfths), one-third would be .4 (four twelfths) and one-sixth .2 (two twelfths). Besides these are two-thirds (.8, eight twelfths), three fourths (.9, nine twelfths), and five-sixths (.X, ten twelfths), all of which could be expressed by a single duodecimal place. Eighths would require only two duodecimal places. One-eighth would be .16 (sixdeen grossths, translated 18/144) and one-sixteenth (one fourdeenth duodecimal) would be .09 (nine grossths).

Fifths, sevenths, tenths, and elevenths would make circulating duodecimals, but as they are less important divisions, and as sevenths and elevenths produce circulating decimals anyway, there would not be much loss.

But what is the use of all this? The decimal system is so thoroughly established that we cannot hope to change it, and besides if we could, would it be worth while? Perhaps not; but this should teach us independence of thought. It should teach us to get down to fundamentals in laying our premises. The fact is that the decimal system is but the arbitrary invention of man, a graven image set on a pedestal. We are such slaves to habit, slaves to precedent, slaves to custom, that we are prone to mistake customary forms for axioms. We are such slaves to authority that we are prone to take things as they are presented to us as matters of fact without going behind the scenes to investigate. Thousands before Newton's time saw apples fall from trees without asking why.

It is well to bow to authority but it should be the bow of courtesy and not the obeisance of the slave. Let us bow to authority but let us not *kneel* to any save the authority of the Eternal, for He has commanded that we have no other gods before Him.

To Mathematics Teachers:

Copies of the recent article by Professor David Eugene Smith, on the oldest English algorism, with facsimile pages, will be sent gratis to those interested in the history of arithmetic, on application to The Secretary of Teachers' College, Columbia University, New York City.

IMAGINARY QUANTITIES IN ELEMENTARY MATHEMATICS.[1]

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Introduction. The introduction of imaginary quantities in elementary algebra has become traditional, and a discussion of these numbers is given usually as a matter of course, without particular forethought, and without a thorough discussion of the importance or of the necessity of the work from the standpoint of the elementary student. The purpose of this paper is to review the reasons for and against this topic, and to state clearly certain fundamental facts.

No knowledge of the theory of imaginary numbers, or of the theory of functions, will be presumed, nor will that theory be touched upon in this paper. The elementary properties of imaginary numbers, on the other hand, will be assumed as known to all present. The teacher may well know facts beyond the range of the student—if such facts are mentioned in what follows it will be understood that the statements are for the teacher rather than for the student. The student will be affected principally by our conclusions.

The Number System—Real Numbers. Statements concerning the origin of our present number system have grown trite. The positive integers arose through counting; the rational fractions were introduced *via* measurement; irrational (or incommensurable) numbers and were recognized gradually from a sense of continuity in geometry; zero and the negative numbers were invented in order to generalize subtraction; and various systems of complex numbers, including the ordinary system of imaginaries, were introduced for reasons dwelt upon later in this paper.

The previous statements concern the historical origin rather than the logical development of the number system. The logical development of the number system, naturally enough, can be made somewhat simpler than this historical development; it would be deplorable if no simplifications had been discovered. Thus, all rational numbers, the positive and negative integers and fractions, and zero can be thought of as arising from the four fundamental operations (multiplication, addition, subtrac-

[1]Address delivered before the Missouri Society of Teachers of Mathematics and Science, December 30, 1908, in Kansas City.

tion and division) applied to the single number 1, there being a finite number of operations to produce a given rational number. Again, all irrationals can be got from the rationals by means of the so-called Dedekind cut[2], or by limit processes[3]. These two schemes alone define all rational and irrational real numbers, i. e., the so-called *real number system*[4].

The real number system thus described corresponds precisely to the numbers defined by terminating and non-terminating decimals of the ordinary decimal system. Familiarity with the decimal system is all that is needed for full comprehension of the entire system of real numbers, except for advanced theoretical purposes. It is for this reason that the preceding statements are not elaborated; they need not be, for you will be quite correct in thinking of ordinary decimals when real numbers are mentioned. This system of numbers is thus easily comprehensible, even to a young student. Statements made will scarcely be misinterpreted, and accurate ideas are readily formed regarding these numbers.

To illustrate the possible precision of statement in real numbers, let us review some elementary facts. Given any two real numbers, each of the four fundamental operations can be performed uniquely, i. e., $A \times B$, $A+B$, $A-B$, $A \div B$, are each definite real numbers, except that division by zero is impossible. The equation $Ax+B=0$ has a single solution $x=-B/A$ where A, B, x are all real, except when $A=0$. The exceptions in these statements should be noted; a later attempt to make general statements will not succeed in removing these exceptions.

Passing now to quadratic equations, there is still no difficulty in making clear-cut, precise statements in terms of real numbers. For, given the equation $ax^2+bx+c=0$, it is shown by the usual process that any possible solution of this equation must be given by the formula

$$x = -\frac{b \pm \sqrt{b^2-4ac}}{2a} \qquad (\text{if } a \neq 0)$$

We shall denote the radical expression by the Greek letter $\triangle = b^2-4ac$. The numbers a, b, c being real, the preceding formula gives two solutions in real numbers if $\triangle > 0$, one solution if

[2]Dedekind, Was sind und was sollen die Zahlen? This "cut" process is reproduced in most modern works on Higher Arithmetic or Function Theory. See, e.g. Veblen & Lennes, Introduction to the Theory of Functions; Pierpont, Theory of Functions, etc. Dedekind's work is published in English translation by the Open Court Co.

[3]The so-called "Fundamentalreihen" of Weierstrass; see any of the above references.

[4]On the whole subject, see also Fine, College Algebra.

$\triangle = 0$, no solution if $\triangle < 0$; for if $\triangle$ is positive, there is a real number whose square is $\triangle$, but if $\triangle$ is negative, there is no real number whose square is $\triangle$. Hence the quadratic equation has (in real numbers) two solutions if $\triangle > 0$, one solution if $\triangle = 0$, no solution if $\triangle < 0$; and the formula (1) gives any solutions which do exist. A verification by actual substitution is immediate.

These statements, though somewhat varied, are precise and vivid; there can be no misinterpretation nor any mystery about them. Nor will the student be forced at any time to retract them, or to declare them false. We shall see that different forms of statement are equally possible, but also that they do not in any wise conflict with these statements.

It is at this point that imaginary quantities find their way into the usual elementary course. If I have made clear that there is no binding *necessity* for introducing them, we can better discuss the *reasons* for their introduction.

THE REASONS FOR IMAGINARIES. Another disturbing and fallacious intuitive feeling which I would ask you consciously to eject from your minds is that numbers, of all kinds, exist without being made. We are speaking as human beings; as such, no numbers exist until some human being invents them. Of philosophy I will not speak in detail, since this is a question of common sense rather than of philosophy; but should I choose, I might lay the strictest philosophic foundation for this statement. Man's numbers are man-made; whether they exist outside of man is immaterial; this one thing I know, that the numbers of of the human race are, or were, made, invented, by men. Man can and has invented number systems of great complexity. The real number system itself is an appalling structure upon close examination. The complex or ordinary imaginary number system usual in algebra is still more complex. Beyond this, and including it, other number systems have been invented and used to good purpose: quaternions, invented by Hamilton; the linear associative algebras of Benjamin Pierce; the vector-algebras of Grassman and others. The fact that these various number systems have been invented does not mean that they exist of themselves, without invention. The God-given power, the God-like power to invent complicated number-systems does not mean that all mankind is forced to think in the most complicated one that has yet been invented. The beautiful invention

of the ordinary imaginary number system still leaves man free to work in real numbers, if he will, free to state truths in real numbers until he explicitly *desires* to invent the imaginary ones; *and be it writ in large that imaginaries do not exist till they are invented,* else all mankind would likewise be forced to admit the constant existence of the most complicated number systems yet devised.

Not precisely the question of whether we shall use imaginaries, but rather the question as to *when* we shall use them, when we shall *invent, introduce,* imaginaries, confronts us. Shall this be during the elementary course on algebra? For what reasons?

It is usual to say that imaginaries are introduced in order that we may make a general statement that every quadratic equation has two roots. I shall combine this with other similar statements, and I shall say that *the first reason* for the introduction of imaginaries is *the desire to make general statements.* We shall see that there are stronger reasons than this.

A second reason is that we desire that every question in algebra shall have some solution; in particular, that the quadratic should have at least some solution; whereas, in the real number system, it has none under certain circumstances. I shall say that the second reason is a desire *that problems should be solvable.*

Probably the most potent reason for the introduction of imaginaries is one seldom pressed as a reason, namely, that there is a profound connection between the theory of imaginary numbers and the theory of many a physical phenomenon. Leaving aside higher illustrations, I would point to the similarity, nay, the identity which exists between the rule for addition of imagaries, and the parallelogram law in physics. For imaginary quantities, like forces and other vectors, are added by the parallelogram construction. This is the first of a mighty and ever increasing chain of the most surprising applications of imaginary quantities in physics. The reasons for the existence of such applications I shall not discuss. Suffice it to say that reason exists, and that reason is more compelling than the puerile desire for a will-o'-the-wisp generality.

To discuss these reasons in reverse order I have remarked that the last one is probably the most compelling of all. It is clear, however, that its force does not become manifest until the

student has advanced considerably beyond the elementary course in algebra. In fact, the application to the parallelogram law for addition of vectors is about the only physical application which could be made in the high school or in the first years of university work. And, probably, the parallelogram law comes as readily for itself as does the law for addition of imaginaries. This reason, compelling as it is in the end, does not apply, then, to high school instruction.

The desire that all problems be solvable is distinctly human. It smacks of the "nature abhors a vacuum" fallacy of physics, and it is just as misleading. For, strive as we may, a system in which all problems are solvable, is not attainable, or has not been attained. A first exception is found in the problem: To divide a number different from zero by zero. The problem cannot be solved, at least not without the introduction of uncanny infinities which are weird even to our modern savants. There are pairs of linear equations in two unknowns which have no solutions; a synonymous fact in geometric language is that there are pairs of lines in the Euclidean plane which do not meet. Equations without solutions must forever exist, not only in the instances mentioned, in the most complete form of the theory of imaginary numbers, such equations without solutions exist. The equation $e^z=0$, the equation $\log z=0$, and many other equations have no solution in the field of imaginary numbers.

While this is true, and while there is nothing fundamentally shocking in an equation which has no solution, there is unquestionably a considerable advantage in general forms of statement. The desire to state theorems without making special cases is strong; thus it seems delightfully simple to say that every equation of degree n has just n roots. The reasons are the beauty of the broad, sweeping statement, and the simplicity attained in stating results. I am in complete sympathy with this view, and there can be no possible question but that any *final* discussion of algebraic equations should lead precisely to these results. If I seem to contradict this in what follows, let it be understood that I refer in this paper to the elementary treatment of algebra for secondary schools. It is apparent that a process may be extremely valuable, yet have no place in secondary instruction. It is not saying that a topic is unworthy of a place in mathematics if we say that it is not suitable for a fifteen year old child.

The facts regarding quadratic equations in real numbers can

be stated with clearness and precision, as we have seen. Let us see whether a simple and accurate presentation is usual in the field of imaginary numbers.

In the real number system, let the quadratic $ax^2+bx+c=0$ be any equation of this form, where a, b, c, are real numbers

two $>$
and $a \neq 0$. Then there are one solutions if $\Delta = b^2 - 4ac = 0$.
no $<$

These statements are wholly within the realm of real numbers.

After the introduction of imaginary numbers, these results are often stated in the following misleading form: "Let us consider the quadratic $ax^2+bx+c=0$, where a, b, c are any numbers; then there are always two roots, and these

both real $>$
are real and equal if $\Delta = b^2-4ac=0$." Probably this statement
both imaginary $<$

would pass as correct in many a test; it is contained, essentially, in many a text-book. It is vitally false; the fact that it is usually accepted in this form only shows that the real meaning is too abstruse for the uses of secondary instruction. For, since imaginaries must have been introduced before this statement is possible, it follows that an unrestricted number may have an imaginary value; in other words, the field of numbers is the ordinary imaginary number field. Hence a, b, c, which are "any numbers," may have imaginary values. An examination of the preceding statement shows that it is not correct: *e. g.*, the equation $x^2-ix=0$ gives $\Delta = -1$; hence the roots should be both imaginary; as a matter of fact the roots are 0 and i; the test stated above is clearly false in such a case. No particular effort is necessary in writing down such equations; the equation $x^2-2ix-1=0$, for example, gives $\Delta = 0$, yet the only root, $x=i$, is imaginary.

Doubtless anyone will recognize at once that this failure of the test as stated arises from the fact that the equations mentioned have coefficients which are imaginary. Indeed it is evident that the only correct form of the preceding statement is one in which we work consciously in two different number systems at the same time; the coefficients being selected from the real field, the roots lying in the imaginary field. Now it is the writer's experience that very few students, and not all teachers, have clear ideas which differentiate the real number

system from the complex number system in such a way as to enable them to pass with great rapidity from considerations which are correct in one of these systems to considerations which are correct in the other. Does it seem probable that the student will gain correct notions from the preceding statements, whether accompanied by the proper explanations or not?

The statement that a quadratic has "two equal roots" is, of course, at best a mere fiction or agreement to use a well-sounding phrase. In case $\triangle = 0$, there is just one root, namely $-b/2a$. There is no other. The writer sees no objection to the use of such a fiction, provided it is really understood by all. Often, however, the student is deceived into a belief that there are actually two roots even in this case; such a misunderstanding confuses rather than illuminates the real fact.

To sum up, the remaining purpose in the introduction of imaginaries was a desire for generality, particularly in the statements regarding quadratic equations. We have seen that the attempt results in a statement that "every quadratic has two roots," and that this statement involves a fiction, the fiction of "two equal roots," which is commonly misinterpreted. Moreover, the attempt to differentiate the cases when $\triangle = 0$ leads to a statement of apparent generality, quoted above, which is true only for coefficients in the real field. Thus the search for generality leaves us still without true generality, since no statement whatever is made about the large class of quadratics which we have incidentally admitted with the admission of the new number system, those with imaginary coefficients. This gap can be filled. Let there be no doubt that the writer sympathizes enthusiastically with the *final* discussion *via* imaginaries. But the gap is not filled in elementary work, nor is it reasonable to do so. Hence the total result of the attempt for generality is to raise a further lack of generality, and to leave our final statements in uncompleted, unclosed form. Moreover, the effect upon the student, and upon some teachers, is to conceal the real truths behind a mask of apparent generality; perhaps even to induce him to believe that his partial knowledge is complete.

As over against this, I might reiterate that the statements made above for real numbers hold for all quadratics in the field, and that there is a completeness in those statements which the corresponding statements in the imaginary field do not possess.

CONSISTENCY IN OTHER TOPICS. In other topics treated in elementary algebra, there is a curious lack of consistency in this matter of imaginary quantities, *i. e.*, in the question of which field of numbers is being considered.

In the extraction of roots, for example, we start with the fact that (1) any number has just one root of any odd order, (2) any positive number has two roots of any even order, (3) a negative number has no root of an even order, (4) any root of zero is zero, in the real number field. These statements are complete in themselves and correct.

When the transfer to the imaginary number field is made, there is rather strenuous insistence upon the fact that even roots of negative numbers exist. Often, little is said about the rest of this scheme; the student is usually left with extremely incomplete ideas of the maze of facts to which the introduction of imaginaries leads. One finds cube roots still taken without any accounting for the new cube roots introduced with the new field. One finds little concerning the simplest extractions of roots of imaginaries. Nor is it reasonable to expect that any real account of the extraction of roots in the (new) imaginary field can be given in the high school. Again here, the search for a generalization which is in itself quite unnecessary leads to a situation which is necessarily more uncompleted, less closed, than the situation in the real number system. Let no one impute to the writer a lack of entire enthusiasm for the *completed* system in imaginary numbers. It is rather the incomplete, hazy system of our usual course in elementary algebra which fails to arouse enthusiasm in anyone acquainted with the facts.

In the treatment of factoring, the first work is usually performed in the real number field, *i. e.*, the coefficients are presumably real. Later, after the introduction of imaginaries, quadratic forms are often factored in the sense of the imaginary number field, *i. e.*, with imaginary coefficients. Yet the theorem, "The sum of two even powers is not factorable," which is true in the real field, is stated often at a still later point. Nor is the usual work in H. C. D. or in reduction of fractions to lowest terms, treated with a desirable degree of clearness. To be sure, it is rather unreasonable to expect that these topics should be clearly presented in the imaginary field to the elementary student. Again I make the point that these same topics can be

treated with reasonable completeness in the real number field. However, the reason that I have mentioned this whole topic is to point out that imaginary coefficients are specifically admitted in the factoring of general quadratic expressions; for this reason, it is unpracticable to restrict ourselves to real coefficients throughout, if we are working in the imaginary field; hence the failure of the test mentioned above cannot be covered by a general agreement that coefficients throughout are to be real.

Finally, in the treatment of logarithms, it is usual to say that a positive number has just one logarithm, and that the logarithm of a negative number does not exist. These statements are correct in the real field. They are not correct in the imaginary field.

Has a quadratic equation always two solutions? Perhaps there are still those among you who feel that this question has an absolute answer, such that that answer and no other answer is correct. Let me then leave with you this last dilemma. In the system of reals, (a) there exist many quadratic equations with no solution whatever; and (b) there exist many numbers, *i. e.*, the negative ones and zero, which have no logarithms. In the imaginary number system, (*a*) every quadratic, with our fiction concerning the case of "two equal roots," has just two solutions; *and* (*b*) every number except zero has an infinite number of logarithms. It follows that if any one of you feels that it is everlasting truth that a quadratic has always two solutions, that one must also hold that every positive or negative number possesses not only one logarithm, but an infinite number of logarithms. On the other hand, if you agree that we may work at will in either the real field or the imaginary field, any of the preceding statements becomes a truth for that field.

If I have called forcibly to your attention the sharp distinctions between the facts in one of these fields and those in the other; if I have made clear that neither field has any mysterious ultimate "truth" in it which makes it in any wise superior to the other; if I have pointed out that inconsistencies and incompletenesses are abundant and necessary in an elementary treatment of the imaginary field; if I have made clear that the facts in the real field are capable of clear-cut, precise, and completed statement, and that a treatment of the real field is amply sufficient and abundantly complicated, even for the disciplinarian, I have attained my purpose.

DEFINITION OF REQUIREMENTS IN ELEMENTARY PHYSICS.

The Definition of the Requirements in Elementary Physics as presented by the College Entrance Examination Board has been criticised for a number of years by teachers of physics and others familiar with the work of the schools.

In an endeavor to secure a better definition, a commission was appointed to consider the matter and to prepare a satisfactory outline of requirements for a course in elementary physics. This commission was composed of ten delegates from the various college associations and the examination board.

After a preliminary investigation of the subject, the Commission met in New York May 1 and 2, 1908, and prepared a definition as a majority report. A vigorous minority report dissenting from the views of the majority was handed in by the representatives of the North Central Association.

Among the contentions of the minority was the plan of referring the definition of the unit in elementary physics to a committee of six or more "successful and experienced teachers of physics who are at present actively engaged in teaching physics in public secondary schools."

This idea finally prevailed and a committee of six secondary school teachers of physics was appointed. To this committee were referred the majority and minority reports of the Commission.

After consideration of these reports and an exchange of views by correspondence, the committee met in New York April 10, 1909, and prepared the following definition.

This definition has been accepted by the College Entrance Examination Board and becomes effective for examination in 1910.—(Editor.)

New York City, April 10, 1909.

To the College Entrance Examination Board:

Your Committee of Secondary School Teachers, to whom were referred the Majority and Minority Reports regarding a Definition of Requirements in Elementary Physics, beg to report that they have given these Reports full and careful consideration and now submit the attached statement of the Physics unit for your approval.

In submitting this report, we desire to call attention to the following points:

(1) The report has received the unanimous approval of the Committee.

(2) We recommend that the College Entrance Board no longer undertake the marking or examination of the laboratory notebook. (See form of Certificate recommended in lieu thereof.)

(3) We urge upon those who prepare the examination questions that these be so planned that students who have received fair preparation on the work as here outlined may reasonably be expected to pass.

Respectfully submitted,

N. HENRY BLACK, *Chairman*, Roxbury Latin School, Boston.
W. M. BUTLER, *Secretary*, Yeatman High, St. Louis.
WINTHROP E. FISKE, Phillips Exeter Academy, Exeter, N. H.
DANIEL E. OWEN, William Penn Charter School, Philadelphia, Pa.
WILLIS E. TOWER, Englewood High, Chicago.
FRANK B. SPAULDING, Boys' High, Brooklyn, N. Y.

Physics.

GENERAL STATEMENT.

1. The Unit in Physics consists of at least 120 hours of 60 minutes each. Time spent in the laboratory shall be counted at one-half its face value.

2. The Course of Instruction in Physics should include:

(*a*) The study of one standard text-book, for the purpose of obtaining a connected and comprehensive view of the subject. The student should be given opportunity and encouragement to consult other scientific literature.

(*b*) Instruction by lecture table demonstrations to be used mainly for illustration of the facts and phenomena of physics in their qualitative aspects and in their practical applications.

(*c*) Individual laboratory work consisting of experiments requiring at least the time of 30 double periods. The experiments performed by each student should number at least 30. Those named in the appended list are suggested as suitable. The work should be so distributed as to give a wide range of observation and practice.

The aim of laboratory work should be to supplement the pupil's fund of concrete knowledge and to cultivate his power

of accurate observation and clearness of thought and expression. The exercises should be chosen with a view to furnishing forceful illustrations of fundamental principles and their practical applications. They should be such as yield results capable of ready interpretation, obviously in conformity with theory, and free from the disguise of unintelligible units.

Slovenly work should not be tolerated, but the effort for precision should not lead to the use of apparatus or processes so complicated as to obscure the principle involved.

3. Throughout the whole course special attention should be paid to the common illustrations of physical laws and to their industrial applications.

4. In the solution of numerical problems, the student should be encouraged to make use of the simple principles of algebra and geometry, to reduce the difficulties of solution. Unnecessary mathematical difficulties should be avoided and care should be exercised to prevent the student's losing sight of the concrete facts, in the manipulation of symbols.

Syllabus.

The following is a list of topics which are deemed fundamental and which should therefore be included in every well planned course of elementary physics. Only a few of the most important applications of these topics have been mentioned; teachers should add liberally to them. It is expected that the teacher will arrange these topics in such order as to suit his individual needs.

I. INTRODUCTION.

A. Metric System.

Linear measure, units:—meter, centimeter, millimeter.

Square measure—square centimeter.

Cubic measure—cubic centimeter, liter.

Mass:—kilogram, gram.

B. Volume, weight, density.

C. States of matter: solids, liquids, gases.

II. MECHANICS.

Fluids.

A. Pascal's Law of Fluid Pressure. The hydraulic press.

B. Pressure due to gravity.
Pressure varying with depth and density of the liquid.
Total pressure on the bottom of a vessel.
C. Principle of Archimedes.
D. Specific gravity of solids and liquids.
E. Gases—relation between pressure and volume.
F. Atmospheric pressure, buoyancy, the barometer, pumps for liquids and gases.

Solids.

A. Principle of moments.
Parallelogram of forces (Resolution of forces, rectangular only).
B. Newton's Laws of Motion.
Force, momentum, velocity, acceleration.
Uniformly accelerated motion, when initial or final velocity is zero.
Falling bodies.
C. Mechanical work.
Energy—potential and kinetic.
Conservation of energy.
D. Machines: Principle of work applied to machines, mechanical advantage, friction, efficiency. (Use terms, effort and resistance.)
Lever, wheel and axle, pulleys, inclined plane.
E. Uniform circular motion; centrifugal and centripetal forces qualitatively illustrated.
F. Law of universal gravitation.
Relation of weight to mass.
Center of gravity.
Stability.

III. Heat.

A. Heat—a form of energy.
Temperature, Centigrade and Fahrenheit scales.
B. Conduction, convection and radiation.
C. Expansion of solids, coefficient of linear expansion.
Expansion of liquids, anomalous expansion of water.
Expansion of gases, Law of Charles, absolute zero.
D. Change of state.
Fusion, the melting point.

Vaporization, boiling, evaporation.

E. Measurement of heat, latent and specific heat.

F. Mechanical equivalent of heat.

IV. Sound.

A. Nature and origin of sound.

B. Pitch, loudness, quality.

C. Velocity.

D. Reflection of sound, echoes.

E. Resonance.

V. Light.

A. Definitions:

Light, luminous bodies, illuminated bodies, transparent, translucent and opaque bodies.

B. Rectilinear propagation of light in a homogeneous medium, shadows, pinhole camera.

C. Photometry.

Intensity of light (source) and intensity of illumination distinguished.

Law of inverse squares.

D. Reflection.

Law of reflection. Regular and diffused reflection.

Plane and spherical mirrors, position and character of images.

E. Refraction.

Laws of refraction (Qualitative)

Refraction by plates, prisms and lenses.

Lenses: Converging and diverging, conjugate foci, principal focus, principal axis.

Position and character of real and virtual images formed by converging lenses.

Dispersion, color and the spectrum.

Applications: The camera, the human eye, the compound microscope, the telescope.

VI. Magnetism.

A. Magnets, permanent and temporary.

B. Polarity, magnetic attraction and repulsion.

C. Magnetic induction, magnetic field and lines of force, permeability.

D. The earth as a magnet, compass, declination, dip.

VII. Static Electricity.

A. Electrification by friction; two kinds of.

B. Electrical attraction and repulsion; electroscopes.
C. Conductors and insulators; electrification by induction.
D. Condensers.

VIII. CURRENT ELECTRICITY.

A. Simple voltaic cell.
Electro-chemical action.
Local action and polarization; prevention of polarization.
B. Types of cells (Daniell, Leclanché.)
C. Electrolysis.
The ampere.
Electrolysis of water, electro-deposition of metals.
Storage cell.
D. Electro-magnetism.
Magnetic field around a current.
Relation between direction of current and lines of magnetic force.
Electro-magnets, ampere turns (qualitative).
The electric bell and the telegraph.
E. Resistance.
The ohm.
Ohm's Law.
The volt.
Power:—the watt and watt hour.
F. Heating effects.
Fuse wire and electric heater.
Arc and incandescent lamps.
G. Measuring instruments; galvanometer, ammeter, voltmeter, resistance box.
H. Series and parallel connection of cells, lamps, etc.
I. Fall of potential in a circuit.
J. Electro-magnetic induction.
Direction and magnitude of the induced electromotive force.
Simple two-pole dynamo and motor.
Simple alternating and direct current generator.
Transformer, induction coil, telephone.

List of Experiments.

MECHANICS.

1. Weight of unit volume of a substance, prism or cylinder.

2. Principle of Archimedes.
3. Specific gravity of a solid body that will sink in water.
4. Specific gravity of a liquid; two methods (bottle and displacement methods).

   Or,
5. Specific gravity of a liquid by balancing columns.
6. Boyle's Law.
7. Density of air.
8. Hooke's Law.
9. Strength of materials.
10. The straight lever, principle of moments.
11. Center of gravity and weight of a lever.
12. Parallelogram of forces.
13. Four forces at right angles in one plane.
14. Coefficient of friction between solid bodies—on a level and by sliding on an incline.
15. Efficiency test of some elementary machine, either pulley, inclined plane or wheel and axle.
16. Laws of the pendulum.
17. Laws of accelerated motion.

HEAT.

18. The mercury thermometer: Relation between pressure of steam and its temperature.
19. Linear expansion of a solid.
20. Increase of pressure of a gas heated at constant volume.

    Or,
21. Increase of volume of a gas heated at constant pressure.
22. Heat of fusion of ice.
23. Cooling curve through change of state (during solidification).
24. Heat of vaporization of water.
25. Determination of the dew point.
26. Specific heat of a solid.

SOUND.

27. Velocity of sound.
28. Wave length of sound.
29. Number of vibrations of a tuning fork.

LIGHT.

30. Use of photometer.
31. Images in a plane mirror.
32. Images formed by a convex mirror.

33. Images formed by a concave mirror.
34. Index of refraction of glass;
 Or,
35. Index of refraction of water.
36. Focal length and conjugate foci of a converging lens
37. Shape and size of a real image formed by a lens.
38. Magnifying power of a lens.
39. Construction of model of telescope or compound microscope.

MAGNETISM AND ELECTRICITY.

40. Study of magnetic field.
41. Magnetic induction.
42. Study of a single fluid voltaic cell.
43. Study of a two-fluid voltaic cell.
44. Magnetic effect of an electric current.
45. Electrolysis.
46. Laws of electrical resistance of wires: Various lengths cross section and in parallel.
47. Resistance measured by volt-ammeter method.
48. Resistance measured by Wheatstone's bridge.
49. Battery resistance—combination of cells.
50. Study of induced currents.
51. Power or efficiency test of a small electric motor.

CERTIFICATE REQUIRED.

In lieu of the presentation of the laboratory note book, at the time of the examination, the candidate must present a certificate in the following form:

TEACHER'S CERTIFICATE.

......................High School

....................190....

I certify that ....has personally performed and properly recorded in a suitable note book .... experiments in the physical laboratory of the ....School, during the year ....

The entire course has occupied time equal to ....hours of 60 minutes each, of which ....hours have been given to the laboratory work and .... hours to lecture and recitation work.

Signed..................................

Teacher of..............................

The teacher may here enter the final grade of ....%.

THE PURPOSE OF THE LABORATORY.

By William F. Evans,

Girls' High School, Brooklyn, N. Y.

We do not desire to turn out from our high schools specialists of any kind whatever—our purpose is to help the pupil to such understanding of physical principles and such knowledge of their practical applications as will give him a profounder realization of his everyday world. If you believe, as I do, that the study physics, if it means anything at all to the average immature, overworked high school pupil should mean a truer knowledge of every day phenomena, a livable acquaintance with his immediate surroundings; if you believe that he will be aided to this knowledge by putting into his hands wherever possible practical applications to physical principles, rather than insisting upon his discovery of arithmetical ratios; if you believe in the identity of purpose of laboratory and classroom, that they mutually aid each other and that their single purpose in secondary schools is to make physics interesting and vital: then the qualitative side of the work will appeal to you and juggling with figures will be like the rattling of dead bones.

What matter whether it is classroom or laboratory where the teaching is done? To give pupils twenty credits out of a hundred for laboratory work seems quite outside of the sense of our teaching. They learn the subject in one place as well as in the other, and they should be tested for their general knowledge and for that only.

How often have we all known pupils, both boys and girls, to come away from the laboratory thoroughly confused as to what they have been doing. They have performed the experiment as directed, have made measurements and computations, adding here, dividing there, just as they have been told to do—for they are perfectly docile—but to what end? They have simply lost their way in the tangle of figures; and the conclusions drawn are senseless to them and so valueless. Figures have obscured facts, and arithmetic has taken the place of physics.

We are teaching elementary physics where the relation between things, the universal relation of cause and effect is vastly more important than the relation between quantities.

AN INVESTIGATION OF THE TEACHING OF BIOLOGICAL SUBJECTS IN SECONDARY SCHOOLS.

By Otis W. Caldwell,

The University of Chicago.

It is frequently asserted that courses in biological subjects. indeed courses in all sciences, have not fulfilled the expectations entertained by those who were instrumental in introducing these subjects into secondary schools. As a part of an attempt to study the general situation the following investigation was undertaken.

A tripartite list of questions was sent to those who are now engaged in teaching biological subjects in secondary schools. The first part referred to the teacher's preparation and experience, the second to the kind of course the teacher is presenting or thinks he should present, and the third to the students' opinion of various aspects of the work. Obviously important difficulties confront one who seeks such information, but it was felt that in order to have the data of value the teachers and students must be its source instead of the administrative officers of the various schools involved. It is also obvious that in this method of securing data important difficulties arise and that the lists of questions must be such as will give reasonable assurance of replies to a fair percentage of the lists sent out. It was not thought wise to attempt to cover by questions some points upon which it is desirable to have accurate data.

A question may arise as to the trustworthiness of the data secured from the students. By reading the direction and lists it will be seen that especial effort was made to secure from the students unbiased expressions, and the nature of the replies indictates that, with possibly one or two exceptions, such were secured.

One hundred sets of the questions were sent out, each set containing one list regarding the teacher, one regarding the course, and five of the "To the Student" lists. The instructions requested that these lists for students be handed to the first five students in the class alphabetically arranged. The schools to which the lists were sent are in central, western, and eastern states and forty-nine reports were secured from teachers and pupils in thirteen states. Those schools not reporting were largely in eastern states. An attempt was made to select aver-

age schools in large, medium sized and small towns. The size of cities and towns from which the forty-nine reports came are as follows: Population under 1,000 (2); between 1,000 and 2,500 (4); between 2,500 and 5,000 (9); between 5,000 and 7,500 (4); between 7,500 and 10,000 (none); between 10,000 and 50,000 (18); over 50,000 (12). It must be kept in mind, however, that it is probable that the better teachers are the ones who replied and that these may often be in larger schools. Two hundred forty-three student reports were received, one hundred four of these being from boys and one hundred thirty-nine from girls.

In preparing the summary of the reports it was often necessary to reduce all the answers to a given question "to lowest terms" by selecting the chief factors in the replies. While these do not appear within quotation marks, they are faithful to the content of the answers. Answers that are taken in the exact form in which they were given are within quotation marks.

In the large amount of work requisite to a faithful summation of this data I have had the valuable assistance of Mr. C. W. Finley, one of my students, to whom in this connection I wish to express my gratitude.

A copy of the questions follows:

In the hope of securing data on the teaching of botany and zoölogy which shall be as accurate as possible, this questionaire is being sent to you and to a number of other teachers. The success of the endeavor will depend upon you and your fellow biology teachers. If you will help by taking the time and trouble to answer as accurately and fully as possible these questions, and to add on the back of the sheet any suggestions you may have that are not called for by the questions, you will contribute much. Furthermore, if you will hand the five "To the Student" blanks to the first five students in your class, beginning with the A's, collect these and return them with your reply, you will assist in giving a new angle of vision upon this problem. In case you do not have a class in botany or in zoölogy, will you please hand the blanks to the students in the last class you had in either subject. It is desired that these blanks be filled out by the students *at once and without any consultation with anyone.*

The results of this inquiry will be summarized and will in some form be furnished to those who request copies of the summarization. In this summarization or report, names of cities, teachers and pupils will be omitted.

TO THE TEACHER.

1. Name.
2. Address.
3. School in which employed.
4. Institution, or institutions in which you received your preparation for high school teaching.
5. Did you prepare especially to teach biology?
6. In what particular biological science (botany, zoölogy, physiology) did you do most of your work?
7. If your special preparation was in other than biological subjects, state what the subjects were.
8. What subjects are you now teaching?
9. How long have you taught botany or zoölogy in this school?
10. In any school?
11. In how many schools have you taught botany or zoölogy?
12. Since beginning your teaching of these subjects, what further preparation have you made for work in biological sciences?

THE COURSE.

1. Indicate whether your course is a half-year of botany and a half-year of zoölogy, a year in botany and zoölogy, or a course in general biology.
2. In what year of the high school course are these subjects being taught?
3. What plan of course do you use? *i. e.*, first text-book study, laboratory, field or class study; study of higher or lower forms; study of habits or of structures; as outlined in what book?
4. What proportion of your course is given to class-room work? Laboratory work? Field work?
5. Is this plan satisfactory to you?
6. If not, what would be better?
7. Are there limitations on your having as much as you wish of your work in laboratory and field? What?
8. To what extent are you at liberty to use the text-books of your own choice?
9. To what extent in organizing your course are college entrance requirements taken into consideration?
10. What do you think the leading purposes should be in teaching botany or zoölogy in high schools?
11. As the subjects are taught, do you think these purposes are met?
12. What is your opinion of the proposed introduction of economic, industrial, and agricultural material into the courses in botany and zoölogy?
13. Are students interested in botany and zoölogy equally with other subjects of the curriculum?
14. What proportion of your students after going to college have elected these subjects there?
15. What do you think are the chief difficulties in the way of a more successful study of botany and zoölogy by high-school students?

Will the teacher kindly hand this blank to the student, asking the student to fill it out at once without consultation with anyone?

To the Student.

1. Name.
2. Address.
3. School.
4. In what year of high school are you?
5. What subjects are you now studying?
6. Which do you like best?
7. How long have you studied botany or zoölogy?
8. After this course would you prefer to continue your work in botany or zoölogy by taking another course in either subject? Why?
9. What part of the zoölogy or botany work do you like best?
10. What part do you find least interesting?
11. What parts do you think are least valuable? Why do you think so?
12. Do you think your study of botany or zoölogy will be of any advantage to you after you are out of high school? If so, what?
13. What do you expect to do after you are out of high school?
14. Why did you study botany in the high school?

The Teacher.

According to the terms of the questionaire the names of teachers and their schools are not to be published, therefore question four is the first one with which we are now concerned. It is:

4. In what institution or institutions did you receive your preparation for high school teaching?

Some teachers did not report upon this point. Of the forty-nine teachers but two report no work in preparation beyond the common elementary schools, and all the others report some work in normal school, college, or university. The total report averages a little less than two institutions above the high school attended by each of the forty-nine teachers. Only three master's and seven bachelor's degrees are reported, these being held by seven teachers, three of whom held two degrees, but probably in the absence of direct request for data upon this point, several who have degrees from colleges and universities did not report that fact. More than one-fifth of all reporting have been students in normal schools. The cosmopolitan nature of the training of these forty-nine teachers is suggested by the fact that while many do not mention the particular institution which they attended, those who do name the specific institutions in all name fifty-one different institutions in which their training was received. This indicates a variety of training such as might be

expected to result in a wide range in conception of the function of biological subjects in secondary schools.

5. Did you prepare especially to teach biological subjects?

No	19
Yes	27
Indefinite answers	3

6. In what particular biological sciences did you do most of your work?

Botany	16
Zoölogy	15
Botany and zoölogy	9
Equal in each	3
Physiology	4
Zoölogy and physiology	1
No reply	1

An apparent discrepancy between answers to No. 6 and No. 5 perhaps is explained by the fact that while a good many who are teaching biological sciences did not prepare for teaching this work, they nevertheless report having had some training in these subjects.

7. If your special preparation was in other than biological science, state what the subjects were.

It was especially for biological sciences	27
It was "general" training	4
It was in chemistry	4
It was in mathematics	4
It was in physics	2
It was in physics and mathematics	1
It was in geology	1
It was in geology and history	1
It was in languages	1
It was in English and history	1
It was in English and drawing	1
It was in Latin	1
Not answering this point	1

8. What subjects are you now teaching?

Teaching botany alone	3
Botany and zoölogy	6
Botany, zoölogy, and one other subject	9
Botany, zoölogy, and two other subjects	5
Botany, zoölogy, and three other subjects	1
Botany and one other (not counting the cases above where botany, and another biological subject are taught)	8
Botany and three others (not biological)	3
Zoölogy and one other (not biological)	1
Zoölogy and two others (not biological)	2

Zoölogy and three others (not biological)	1
Zoölogy and four others (not biological)	1
Not now teaching any biological subject	1

The detailed data show that with these forty-nine teachers thirty-one different combinations of the subjects taught are presented. Practically every subject within the wide range of high school curricula is in some case associated with botany in the hands of one teacher, or perhaps it should be said that botany is found in the hands of the teacher of practically every subject in high school curricula.

The number of subjects taught by these teachers is suggestive:

Those teaching but one subject	3
Those teaching two subjects	15
Those teaching three subjects	19
Those teaching four subjects	9
Those teaching five subjects	2
Combination not reported	1

9. How long have you taught botany or zoölogy?

Those in first year of teaching of botany	13
The average number of years of teaching botany in one school (excluding the thirteen who are in their first year in their present school)	7 years.
Longest period of teaching botany in one high school	18 years.

10. How long have you taught botany or zoölogy in all high schools?

Average (excluding those who are in their first year of teaching)	9 years.
Longest period of teaching botany in all high schools..	21 years.

11. In how many schools have you taught botany or zoölogy?

Average (excluding those who are in their first year of teaching botany or zoölogy).....	2⅗ schools.
Largest number of high schools in which one teacher has taught botany or zoölogy....	6 schools.

The data also shows that the ten who have taught botany longest in the high schools have averaged fifteen and one-fifth years each and that these years of teaching have been in an average of two and two-fifths schools, a number of schools slightly below the average for all teachers (excluding those who are in their first years of teaching). It is also further interesting to note that these ten have prepared themselves specially for the teaching of botany.

11. Since beginning your teaching what further preparation have you made for work in biological sciences?

Ideas as to what may constitute "further preparation" are so diverse that rather full quotation must be made from the reports:

No further preparation	4
University work	23
Read text-books and periodicals	12
Private work	8
Attended biological meetings	4
Collected material	3
Field work	3
Research	3
Work abroad	3
Special work in slide making	1
Tried to keep up with the times	1
No report	3

It will be noted that several teachers have cited two or more kinds of work thus making an aggregate in excess of the forty-nine teachers reporting.

Obviously it would be of interest to make a study of relations that may exist between the teacher's report upon his own training and experience and his report upon what he considers shall be the nature of his course, but such an individual study of reports cannot now be presented.

The Course.

1. Indicate whether your course is a half year of botany and a half year of zoölogy, a year in botany and a year in zoölogy or a course in general biology.

The summarization of replies follows:

One year of botany, no separate course in zoölogy, biology, or physiology	14
One-half-year botany and one-half-year zoölogy	9
General biology, no separate course in zoölogy, botany, or physiology	4
One year of zoölogy, no separate course in botany, biology, or physiology	4
One year biology, one year botany, and one year zoölogy	1
One year botany and one year zoölogy	5
One-half year botany, one-half year zoölogy, and one-half year physiology	1
One-half year botany and one year zoölogy	1
One year botany and one-half year zoölogy	1
One-half year botany alone	2
One-half year botany and one-half year physiology	1
One year botany and one year physiology	1
Two years botany and one-half year zoölogy	1
One year "nearly all zoölogy but a little botany"	1
One-half year botany and one-half year zoölogy plus a full year of elective in each	1
Indefinite	2

It is evident that the above answers show about all the combinations that are possible. There seems to be no danger as yet of too great rigidity in the kinds of courses given. It would be difficult to account for these wide variations upon the basis of adjustment to peculiar local conditions. When we consider, however, that these forty-nine cases present no less than fifteen different combinations it would seem important to find the causes of such variation.

2. In what year of the high school are these subjects being taught?

All the biological work confined to first year	7
All the biological work confined to second year	21
All the biological work confined to third year	2
All the biological work confined to fourth year	2
Botany first year and zoölogy second year	4
Botany first year and zoölogy third year	1
Botany first year and physiology second year	1
Botany second year and zoölogy first year	1
Botany second year and zoölogy third year	1
Botany first and second years	1
Botany second and third years	2
Botany fourth year and zoölogy first year	1
Physiology first year	1
First and second year classes combined, physiology and physiography being given in alternate years	3
No answer	1

3. What plan of course do you use, i. e., first text-book study, laboratory, field or class study, study of higher or lower forms, study of habits or structures; as outlined in what text-book?

The replies upon this topic are necessarily so varied that it is difficult to reduce them to a satisfactory form of presentation, the fault being due probably to the lack of organization of the points involved in the topic. Of the forty-nine replies eighteen state definitely that they follow the work as laid out in text-book and laboratory manual, while eight state that they first take up laboratory work based upon their own outlines, then follow with text-book work, and then have some field work. A small number express a preference for first studying by use of text-book, then having laboratory work upon types discussed in text-book study. The majority present structures first, some following this by a study of physiology and ecology, these being represented by some who say "structure most important, then functions and adaptations." Nearly all begin their work by use of "higher forms" and most follow this by some study of "lower

forms," though some omit the latter from the course. Some study homologies of structures and evolution of higher forms, while some find these things not understandable by high school students.

The previously mentioned wide variation is further emphasized when we note that in botany, zoölogy and general biology (exclusive of physiology) sixteen different kinds of text-books are used.

4. What proportion of your course is given to class-room work, to laboratory work, and to field work?

Most time given to class-room work	15
Most time given to laboratory work	25
Time evenly divided between class and laboratory work	5
Most time given to field work	1
Indefinite replies	3

5. Is the plan as you report it in the preceding section satisfactory to you?

The above plan is not satisfactory	31
The above plan is satisfactory	16
Indefinite	2

6. What would be better than the plan you use?

More field work	19
A longer course	6
More laboratory work	2
Smaller classes	2
A combination of class, field, and laboratory work	2
A greenhouse or a school garden to increase facilities for experimentation	2
More apparatus	1
Not replying to this point	15

7. What limitations are there upon your having as much as you wish of your time in the laboratory or field?

There are no limitations	8
Limited by crowded program either of teacher, or student, or both	29
Lack of adequate laboratory apparatus	7
Lack of adequate room	4
Distance from suitable field region	4
Classes too large	2
Expense of field trips	1
After-school work of pupils	1
No interpretable answer	4

Several teachers reported two or more limiting factors. The most serious difficulty with the amount of laboratory and field work that teachers would like to do is reported as being the difficulty that is had in securing time for these things. This is

due to the interference thus made with other school and home duties both of the teachers and pupils.

8. To what extent are you free to use the text-book of your choice?

No limitations	20
No voice in choosing	13
May choose, subject to approval by school board	10
Indefinite answers or no answers	6

9. To what extent in organizing your courses are college entrance requirements taken into consideration?

Do not consider them at all	23
Plan course to meet college requirements	19
Must meet requirements in state course of study	3
No answer	2
Indefinite	2

It is not possible adequately to quote many of the answers to this question but they range all the way from those who said, "This is all any high school is for," and "We are a part of our state school system and if we don't follow the dictates of the state university we'll be cut off their accredited list and will get no financial or educational support," to those who say that "too much stress is laid upon meeting entrance requirements in science," and "the colleges should accept what we think is best for the students."

10. What do you think the leading purposes should be in teaching botany or zoölogy in the high school?

Emphasized scientific training	17
Emphasized development of love and knowledge of nature	14
Emphasized preparation for more efficient living	9
Emphasized ecological knowledge of plants or animals	5
Emphasized economic relation of plants or animals	4
Emphasized preparation for continued work	2
Emphasized knowledge of evolution	2
Not answering this question	3

This summarization of the purposes given by these forty-nine teachers by no means does justice to their replies, since many of them speak at length and with clearness concerning the purposes they have in mind for the work. The following quotation of phrases indicates more fully the nature of the replies: "Love for nature, pleasure and profit," "structure and habits of living things and their relation to men," "accurate knowledge and love for science," "acquaintance with environment, culture and self-preservation," "knowledge of form, struc-

ture and ecology and classification," "acquaintance with nature and training in scientific thought," "broadening of outlook and practical application," "trend of scientific thought," "scientific observation and practical information," "acquaintance and sympathetic observation and a deeper hold on life," "scientific training," "broad, general and practical information," "to develop independent thinking," "to introduce to a field for future browsing," "to teach organization of systems of plants and animals," "accuracy, evolution and practical work," "economic value of plants both helpful and harmful."

11. As these subjects are taught do you think these purposes are met?

To make the data on this point most meaningful it would be well to associate each teacher's reply with the purpose for which he thinks the courses are given. Such would require more space than can now be used. However, of the forty-nine teachers:

The number believing the purposes they state are met, are	16
The number believing the purposes they state are not met, are	11
The number saying, "Fairly well," or similar expressions, are	19
The number not replying are	3

12. What is your opinion of the proposed introduction of economic, industrial and agricultural materials into the courses in botany and zoölogy?

Those approving are	20
Those disapproving are	5
Those partially approving but strongly expressing doubts in some form	17
Indefinite or not answering	7

Many reasons are cited as: "Not time for this in the course," "favor it, pupils interested in it, appeals to practical and awakens appreciation of course," "only a small amount should be undertaken," "needs of locality should decide," "useful knowledge sustains interest," "adds interest and practical value and does not hinder scientific interest," "danger of crowding in too much and of forgetting our students are young," "the fundamentals and more important things already crowd a year's course," "I disapprove it," "excellent for country high schools," "include it unless a separate course for agriculture be given."

13. Are students interested in botany and zoölogy equally with other subjects?

Yes	30
No	2
More so	12
Don't know	2
"Yes, when not subjected to outside influences"	1
Not answering	2

In examining these answers it must be kept in mind that in many schools the biological subjects are entirely elective and this fact may influence the relative popularity of the work with those who take it. If only those take these subjects who have a strong natural interest in them they will probably think better of the courses than would the average student if all were required to take these subjects.

14. What proportion of your students after going to college elect botany or zoölogy?

To this question nearly all the teachers replied that they do not know what their students have elected in college. Those giving data are not clear as to its accuracy and it will not be quoted.

15. What do you think are the chief difficulties in the way of a more successful study of botany and zoölogy by high school students?

Lack of proficient teachers	12
Lack of more time for work	12
Lack of apparatus	12
Lack of adequate field work	10
Lack of material	7
The position and crowded nature of science in the course	5
Large classes	4
Too little emphasis on economic aspects	4
Not adequate laboratory work	3
Poor text books	3
Lack of good laboratory manuals	2
Ignorance of parents regarding use of botany and zoölogy	2
"Subjects taught as 'makeshifts' by teachers of other subjects"	2
"Teachers too many subjects to teach"	2
"Abhorrence of parents against evolution and descent".	1
"Let pupils do more work and teachers less talking"	1
"Too frequent change of teachers"	1
"Pupils have too many outside interests"	1
"Making work too mature"	1

THE STUDENT.

The total number of students replying to their lists is two hundred forty-three. Of these one hundred four are boys and

one hundred thirty-nine are girls. The names of nearly all of them begin with letters within the first part of the alphabet, thus indicating that teachers followed directions in handing out the blanks. Furthermore, barring the possibility of a single set of student papers the indications are that perfectly fair and dependable methods were used by teachers in securing the kinds of reports that were desired.

The question of the year of the high school in which the biological subjects came was amply covered under The Course.

It must be kept in mind that although two hundred forty-three students reported, not all were having a biological science at the time the report was made. Some reported upon courses previously completed.

2. Number studying botany at time of report 129
   (Of these fifty-three were boys, this being fifty-five per cent of the total number of girls. This indicates that it is not botany, but high schools that seem to be most largely for girls.)
   Number studying zoölogy 59
   (Of these twenty-seven were boys, twenty-six per cent of all boys, and thirty-two were girls, twenty-four per cent of all the girls.)
   Number studying general biology 22
   (Of these twelve were boys and ten were girls.)

English	215
Mathematics	178
History	116
Latin	107
German	69
Physics	21
Drawing	21
Civics	18
Geography	13
Physiology	7
General Elementary Science	5
Music	5
Manual Training	5
Domestic Science	3
Greek	3
Other subjects (including French)	28

6. Which subjects do you like best?

Zoölogy with 59 students has 20 or 34% of those who take it preferring it to all other subjects.
Botany with 129 students has 41 or 31% preferring it.
Mathematics with 178 students has 42 or 24% preferring it.
German...with 69 students has 22 or 31% preferring it.
History...with 116 students has 27 or 23% preferring it.

Latin.... .with 107 students has 14 or 13% preferring it.
English.. .with 215 students has 27 or 12% preferring it.
Chemistry with 15 students has 11 or 73% preferring it.

In all there are sixty-nine preferences of biological subjects (botany, zoölogy or general biology) or thirty-two per cent of the total number of students taking these subjects. This may be misleading owing to a possible tendency on the part of pupils to give a more favorable report to the subjects used as the basis of the questions.

7. How long have you studied botany or zoölogy?

The average length of course of all these students at the time of making the report was a little more than four months.

8. After this year would you like to take a further course in botany or zoölogy?

Yes	150
No	85
Noncommittal	8

Why?

1. Those not desiring a further course:

Of no use to me	19
Not interesting—can't get interested in it, etc.	17
Do not like it	14
Do not intend to specialize in it	4
Other answers of similar nature	31

2. Those desiring to take further courses:

Interesting	82
Think it will be useful	41
Want to know more about it	16
Because I like it	16
Love nature and want to know more about it	7
It will help in study of medicine	2
"Yes, if there is any text-book that takes it up in a more interesting manner"	1

9. What part of the work do you find least interesting?

In these replies practically all aspects of the course are cited by some one or more students as least interesting. The eight leading "uninteresting" features are given:

Lower forms	51
Text-book work	15
Structure	14
Classification and analysis	15
Recitation work	12
Ecology	7
Higher forms	5
Plant societies	5

10. What parts of the work do you think are least valuable to you?

These answers were of such a nature that they could be grouped about factors that were essentially the same though of course not stated in the same way by different students. The eight factors receiving most frequent mention are given:

No part is least valuable to me	21
Lower forms are least valuable	41
Scientific names	14
Structural studies, including morphology	14
Analysis and classification	11
Ecology	8
Physiology	6
Microscopic work	3

The reasons assigned for students' opinions of lack of relative values of the aspects of the course which they think of least value are many, but most interesting. The leading ones are:

Of no use to me, no benefit, not worth while	63
These details are soon forgotten and require too much time for what is gotten from them	15
Not interesting and never seen in practical life	14
Does not help me in what I am going to do	8
Most interesting aspects of the subject should receive more attention	3
Too difficult to learn	3

Some quoted replies may be of interest in giving fully the students' point of view, the first part of the quotations being the student's "least valuable" part of the work and the latter part his reason therefor. "Detailed structures......merely name finding." "Detailed structures......I don't care if there is protoplasm in plants." "Laboratory......too much cutting up to do." "Microscopic work......of no use," an answer which in some form is very common. "Text-book work......cannot understand the book." "Text-book......field work far better." "Text work without laboratory......hard to remember without seeing." "Plant physiology......course not long enough to pay." "Ecology......a person generally knows what he finds is usually found in different regions." "Field work......can be learned from a book." "Drawing......time wasted."

11. What parts of the work do you think are most valuable to you?

Through error in preparing the sheets this question was omitted from most of the sets, hence a small proportion of reports cover this point. In a way a check is secured because the

fact that query ten, the opposite of eleven, was in all the sets. It is interesting to note, however, (1) that some students see no particular value in the work, and (2) that most of them select definitely a particular aspect and give a good reason for so doing. The opinions on this point are widely and generally distributed. Some of the answers follow: "Higher forms...... we can see the higher forms." "Observation......you can see and know for yourself." "Laboratory......you can see and know for yourself." "Memorizing names......develops memory." "Learning parts of animals......can understand general classes of animals." "Study of mammals......most like people." "Leaves and flowers......because I understand them." "Morphology......teaches underlying principles." "Leaves, roots, stems and seeds......they include all the plant." "Textbook work......the writings of important men." "Grafting of plants," "Forestry," "Disease producing plants and animals," "Plant breeding," "Stock breeding," "Economic aspects of plants and animals." The last group of quotations are samples of the kinds of replies that predominate throughout the reports, nearly all students making such statements following with a statement that such things are of more interest and of some use to them.

12. Do you think your botany and zoölogy will be of any use to you after you are out of high school?

Yes	191
No	23
Don't know	9
Not much	8
Probably	5
No answer	2

13. If of any use, what do you think that is?

Pleasure and appreciation of nature	57
Knowledge of nature, ability to read better, etc.	56
Help in future work	42
Will help in raising plants	7
Help to prevent disease	6
Will help to get along better	5
Aids in getting more knowledge	3

14. What do you intend doing when you are out of high school?

Take a college course	80.
Have not decided	40
Teach school	35
Take a course in music	12
Take an engineering course	11

Take a business course	10
To farm	9
Work at home	7
To be a trained nurse	6
Take a medical course	5
Take a domestic science course	5
Be a stenographer	4
Study painting	3
Take an agricultural course	2
Study elocution	1
Be an architect	1
Take a naval course	1
Do not know	40

15. Why did you study botany in the high school?

This question selects one of the biological courses in order to make more definite the replies upon a single aspect of the problem.

"It came in the course," or "it was required," or "to get the credit," or "to use it in getting into college," or "one science is required"	47
Wanted to learn about plants	25
The subject was interesting	18
I took it rather than another subject	12
I thought it would be useful	12
I thought I would like it	10
I always liked nature, or science, or plants	9
"Because I like flowers"	4
I heard others praising the course	3
"Because my friend took it"	1
"Because my teacher advised me"	1
"Because I thought it would be easier"	1
"It was necessary if I became a teacher"	1
"It is something everyone should know"	1
"To broaden my education"	1
"I always liked experimental work"	1
"At first because it came in my course, then because I like it"	1
"I needed the credits" (included above)	
"Because my parents wanted me to"	1

It is obvious to all who have had experience in secondary schools that many inferences are possible from some of these data. In this connection no attempt has been made to present the full meaning of the facts as here shown. These things are presented in the belief that it will help us to know these facts regarding the problem of biological education, and further inference regarding these facts may prove of interest at a later date.

PROBLEM DEPARTMENT.

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Readers of the magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

149. *Proposed by I. L. Winckler, Middlebury, Vt.*

$$x(y+z-x)=a$$
$$y(z+x-y)=b$$
$$z(x+y-z)=c$$

Solution by Ira P. Baldwin, Emporia, Kansas.

$$\frac{(a/x)}{y+z-x}=\frac{(b/y)}{z+x-y}=\frac{c/z}{x+y-z}=\frac{a/x+b/y}{2z}=\frac{a/x+c/z}{2y}$$
$$=\frac{b/y+c/z}{2x}=\frac{ay+bx}{2xyz}=\frac{az+cx}{2xyz}=\frac{bz+cy}{2xyz}.$$

$\therefore ay+bx=az+cx=bz+cy$ by the principle of proportion.

$$\therefore bx+(a-c)y-bz=0$$
$$cx-cy+(a-b)z=0$$
$$(b-c)x+ay-az=0$$
$$\therefore x/a(b+c-a)=y/b(a-b+c)=z/c(a+b-c)=k$$

These values of x, y, z in $x(y+z-x)=a$ gives

$$ak^2(b+c-a)[b(a-b+c)+c(a+b-c)-a(b+c-a)]=a$$
$$\therefore k^2(b+c-a)(a-b+c)(a+b-c)=1$$

$$\therefore k=\pm\frac{1}{\sqrt{(a+b-c)(a-b+c)(b+c-a)}}$$

150. *Proposed by G. B. M. Zerr, Ph.D., Philadelphia, Pa.*

In a certain country the tax per \$1 on a person's income varies as the fourth root of the number of dollars and when the income is \$10,000 the rate per dollar is 10 cents. Find the largest net income possible.

I. Solution by H. E. Trefethen, Kent's Hill, Maine.

I. Practical method. Since $10^4=10000$, the fourth root of the number of dollars of income is the rate of tax in every case. The following table explains itself and indicates the maximum income with sufficient exactness. It is made thus $10^4(1.00-0.10)=\$9000$, etc.

%	Net income	%	Log of net income
30	\$567000	79	6.9125208
50	3125000	79.9	6.9133833
70	7203000	80	6.9133899
80	8192000	80.1	6.9133831
90	6561000	81	6.9126936

II. Algebraic and graphical method. Put x for the rate of tax. Then $x^4(100-x)/100=$ number of dollars of net income. Hence the function to be examined for a maximum is $x^4(100-x)=100x^4-x^5$.

Put $100x^4-x^5=y$,* or $x^5-100x^4+y=0$. Since $y=0$ when $x=0$ or 100 and is positive and finite for all intermediate values of x, y has at least one maximum value between these limits, and since there can be no more than two positive values of x in this equation, y can have only one such value. And when y has this maximum value the two positive values of x must be equal. All we have to do then is to find two equal values for x. Put p, p, q, r, s for the five roots. Then
$2p+q+r+s=100$, $p^2+2p(q+r+s)+qr+qs+rs=0$,
$p^2(q+r+s)+2p(qr+qs+rs)+qrs=0$, $p^2(qr+qs+rs)+2pqrs=0$.
Whence $p=80=x$. $80^4/5=8192000$=maximum net income.

III. Differential method. $x^4(100-x)/100$=max. Hence
$f(x)=100x^4-x^5$, $f'(x)=400x^3-5x^4=0$, $x=80$ and
$x^4(100-x)/100=8192000$=maximum net income as required.

II. Solution by Wm. B. Borgers, Grand Rapids, Michigan.

Let x = number dollars income, t = tax per dollar, $y=tx$, $u=x-y$. Find maximum value of u.

Since $t = cx^{\frac{1}{4}}$, and $10{,}000^{\frac{1}{4}}c = \frac{1}{10}$, $\therefore c = \frac{1}{100}$,

$\therefore t = \frac{1}{100}x^{\frac{1}{4}}$, $tx = \frac{1}{100}x^{\frac{5}{4}}$.

$u = x - \frac{1}{100}x^{\frac{5}{4}}$. $\dfrac{du}{dx} = 1 - \frac{1}{80}x^{\frac{1}{4}} = 0$ when $x^{\frac{1}{4}} = 80$,

$x=\$40{,}960{,}000$, $t=80$ cents, $u=\$8{,}192{,}000$.

The second derivative is negative for any positive fourth root of x, and our value is therefore a maximum one.

Geometry.

151. *Proposed by W. A. Challacombe, Carlinville, Ill.*

Given two circles, with centers O and O′, and a point A in their plane, to draw through the point A a straight line, meeting the circumferences at B and C so that AB : AC = m : n. (From Wentworth's Plane Geometry.)

Solution by M. H. Pearson, Dothan, Ala.

Let the circle O lie between the point A and the circle O′.

Draw AO and produce to P, so that AO : OP = m : n; find the fourth proportional to AO, OP and the radius of the circle O.

With this fourth proportional as radius and P as center draw an arc cutting the circumference of the circle O′. Join this point of intersection to A. Then we have the required line. Proof is evidently easy. The proof is similar when the point A is between the circles.

152. *Proposed by Lloyd Holsinger, Peoria, Ill.*

In a circumscribed triangle the lines joining the vertices to the points of contact are concurrent.

I. Solution by Hamlet P. Collins, Rahway, N. J.

Given a triangle ABC circumscribed about the circle FED and BF, CE and AD straight lines from the vertices to the points of contact, to prove FB, EC and AD concurrent. Through A draw HG parallel to BC. Prolong CE and BF to meet it at G and H respectively. Triangles AEG and CEB are mutually equiangular and therefore

*In plotting the graph of this equation make 1000000, or more, units on the y axis = 1 unit on the x axis.

similar. Hence AG/CB=AE/EB. In the same way CB/AH=CF/AF. By multiplication $AG/AH=\dfrac{AE \cdot CF}{AF \cdot EB}$. But AE=AF, being tangent from the same point. $\therefore$ AG/AH=CF/EB. CF=CD and BE=BD being tangents from the same external point.

$\therefore$ AG/AH=CD/BD. $\therefore$ CG, AD and HB divide the two parallels into proportional segments; they are then concurrent.

II. Solution by T. M. Blakslee, Ph.D., Ames, Iowa.

a. As the sides of the triangle are formed by three pairs of equal tangents, the statement follows from the converse of "Ceva's theorem."

b. As the triangle may be regarded as a circumscribed hexagon having the vertices of the triangle for three vertices and the contact points for the other three, this is a special case of "Brianchons theorem."

Applied Mathematics.

153. *Proposed by G. W. Greenwood, Dunbar, Pa.*

Find the total force against a dam 30 feet long when the water stands 20 higher on one side than on the other.

I. Solution by Walter L. Brown, Fancher, N. Y.

The total exposed area is 20x30=600 sq. ft.; the average height is 10 ft., and therefore the pressure is that of 6000 cu. ft. of water. Reckoning 62½ lbs. for each cubic foot of water, we have 375,000 lbs. = 187.5 tons.

II. Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

If the dam should be treated as a retaining wall the problem has no place in a text on physics, but belongs to the field of strength of materials. Treating the dam as a simple rectangle 30 feet by 20 feet with the pressure on one side we get the pressure P as follows:

$P=\frac{1}{2}h\times h\times a\times w$, where h=height=20 feet; a=length=30 feet; w=weight of a cubic foot of water=62.34 lbs.

$\therefore P=10\times 20\times 30\times 62.34=374040$ lbs.

Treating the dam as a flood gate, let d=depth of water on one side, d_1 depth on other side. Then $d-d_1=20$.

$P=\frac{1}{2}a(d^2-d_1^2)w=\frac{1}{2}a(d-d_1)(d+d_1)w$

$=15\times 20(d+d_1)62.34=18702(d+d_1)$ lbs.

154. *Proposed by Ira P. Baldwin, Emporia, Kansas.*

On a level plain the crack of a rifle and the thud of the ball striking the target are heard at the same instant. Find the locus of the hearer. (S. L. Loney's Coördinate Geom., p. 283.)

Solution by Orville Price, Denver, Colo.

Let A and B be the positions of rifle and target and P one position of the hearer. Designate the length AB by $2c$, and choose the middle point O, of AB as the origin of coördinates and AB as the axis of x.

We have $BP=\sqrt{(c-x)^2+y^2}$, $AP=\sqrt{(c+x)^2+y^2}$.

If b and s are the velocities of the bullet and the sound,

$$\frac{2c}{b}+\frac{\sqrt{(c-x)^2+y^2}}{s}=\frac{\sqrt{(c+x)^2+y^2}}{s}.$$

By proper algebraic reductions this leads to the equation of an hyperbola,

$$x^2(b^4-b^2s^2)-y^2b^2s^2=b^2c^2s^2-c^2s^4.$$

CREDIT FOR SOLUTIONS RECEIVED.

Geometry 147. H. E. Trefethen. (1)

Algebra 149. Ira P. Baldwin, Walter L. Brown, Hamlet P. Collins, E. B. Escott, John Gaub, A. M. Harding, Orville Price, O. R. Sheldon, H. E. Trefethen, James Weaver, J. F. West, I. L. Winckler, G. B. M. Zerr. (13)

Algebra 150. Wm. B. Borgers, Hamlet P. Collins, A. M. Harding, E. Kesner, H. E. Trefethen (3 solutions), I. L. Winckler, G. B. M. Zerr. Also 3 incorrect solutions. (12)

Geometry 151. Walter L. Brown, M. H. Pearson, Orville Price, Roswell W. Rogers, H. E. Trefethen, Jas. H. Weaver, J. F. West, I. L. Winckler, G. B. M. Zerr. (9)

Geometry 152. T. M. Blakslee (2 solutions), Walter L. Brown, Hamlet P. Collins, A. Dawkins, E. Kesner, H. E. Trefethen (4 solutions), J. F. West, I. L. Winckler, G. B. M. Zerr. (13)

Applied Mathematics 153. Wm. B. Borgers, Walter L. Brown, Hamlet P. Collins, H. E. Trefethen, Jas. H. Weaver, I. L. Winckler, G. B. M. Zerr. (7)

Applied Mathematics 154. Walter L. Brown, Wm. B. Borgers, Hamlet P. Collins, E. Kesner, Orville Price, H. E. Trefethen, Jas. H. Weaver, I. L. Winckler, G. B. M. Zerr. (9)

Total number of solutions, 64.

PROBLEMS FOR SOLUTION.

Algebra.

161. *Proposed by John Gaub, Ithaca, N. Y.*

The diameters of the ends of a 24 foot log are 3 and 4 feet. How far from the larger end must it be cut so that it shall be divided in half?

162. *Proposed by H. E. Cobb, Chicago, Ill.*

When the equations (1) $x=y-2+2$

(2) $x-z : y+z=1 : 2$

(3) $$\frac{x-2}{4y-4}=\frac{1}{2}+\frac{z-1}{y-1}$$

are solved by the usual method, the result is $x=2$, $y=1$, $z=1$. The same result will be obtained if in (3) 1/2 is replaced by any positive or negative, integral or fractional number, except 0. If 1/2 is replaced by 0 the problem is indeterminate. If from (1) and (2) one finds $x=4z-2$ and $y=5z-4$, and substitutes these values in (3) z disappears, and he has $1/5=1/2+1/5$, a contradiction. Where lies the error?

Geometry.

163. *Proposed by G. E. Congdon, Hiawatha, Kansas.*

Given the trapezoid ABCD having AB equal to one half the parallel side CD, and K the middle point of BD. To prove the sides of the triangle AKC are equal respectively to the medians of the triangle BCD.

164. *Proposed by T. M. Blakslee, Ph.D., Ames, Iowa.*

The joins of the opposite vertices of a hexagon circumscribed about a circle are concurrent.

Trigonometry.

165. *Proposed by G. B. M. Zerr, Ph.D., Philadelphia, Pa.*

I measure a distance AD=300 yds. The angle BAC=the angle CAD=30 degrees. The angle ADB=45 degrees and the angle BDC=67½ degrees. Find BC without using tables.

NEWS ITEMS.

The members of the International Commission on the Teaching of Mathematics thus far appointed are:

Austria: E. Czuber, R. Suppantschitsch, W. Wirtinger.
Denmark: P. Heegaard.
France: P. Appell, C. Bourlet, C. A. Laisant.
Germany: F. Klein, P. Staeckel, P. Treutlein.
Great Britain: Sir George Greenhill.
Greece: K. Stephanos.
Holland: J. Cardinaal.
Hungary: E. Beke, G. Rados.
Italy: G. Castelnuovo, F. Enriquez, G. Vailanti.
Portugal: G. Teixeira.
Russia: N. J. Sonin, B. M. Kojalovic, M. Vogt.
Spain: Z. G. de Galdeano.
Switzerland: H. Fehr, C. F. Geiser.
United States: W. F. Osgood, D. E. Smith, J. W. A. Young.

ORTHODOX FALLACIES.

By G. W. Greenwood, Dunbar, Pa.

Confining ourselves to the first of the fallacies given on page 397 of the April number of this journal, it is to be observed that the difficulty, like many another in more serious problems of life, arises not merely through doing something one should not do, but which a little thought would show there is no reason for doing. If from the equation $ax=ab$ the student without apology derives the result $x=b$, he shows a lack of care which, in a real problem, might prove disastrous even though it may be the "answer" and may be accepted by the teacher.

Before dividing both members of an equation by a common factor, we *must* either *know* or *explicitly assume* that this factor is not zero. The conclusion from the above equation is $x=b$ if $a\neq 0$, the omission of the latter statement being a fatal defect, even though in accord with current practice.

It is said that there is nothing so unfortunate as activity without insight, yet current tendencies are prone to foster the former rather than the latter.

INTERNATIONAL COMMISSION ON THE TEACHING OF MATHEMATICS.

Preliminary Report of the American Commissioners.

1. Organization.

The Central Committee consisting of Professors F. Klein of Göttingen, Sir George Greenhill of London, and H. Fehr of Geneva, having appointed Professors W. F. Osgood of Cambridge, Mass., David Eugene Smith of New York, N. Y., and J. W. A. Young of Chicago, Ill., as the American Commissioners, the latter held their first meeting in New York City on March 26 and 27, 1909. Commissioner Smith was elected chairman and Miss S. M. Neilson was appointed clerk.

2. Official Organ.

It was resolved to adopt School Science and Mathematics as the official organ of the American Commissioners in the sense in which official organ is defined in the Preliminary Report of the Central Committee, recognizing *L'Enseignement Mathématique* as the official organ of the International Commission.

3. Advisory Council.

It was resolved to form an Advisory Council to which may be referred important general questions and with the members of which the Commissioners may consult collectively or individually as occasion may arise, and to invite the following gentlemen to membership: The United States Commissioner and ex-Commissioner of Education, the Presidents of Harvard, Columbia, and Chicago Universities, and the Presidents and ex-Presidents of The American Mathematical Society, and of The American Federation of Teachers of the Mathematical and the Natural Sciences.

4. Method of Investigation.

It was resolved to carry on the investigation by means of various committees and subcommittees, the chairmen of the latter constituting the members of the former. These committees and subcommittees will consider part or all of the five topics set forth in the Preliminary Report of the Central Committee, viz.:

(*a*) The organization of schools and the general relation of each kind of school to the others;

(*b*) The mathematical curriculum in each type of school;

(*c*) The question of examinations, from the point of view of the school;

(*d*) The methods employed in teaching mathematics;

(*e*) The preparation of teachers of mathematics.

These topics are to be considered for each type of school and grade of work, both with regard to present conditions and reforms proposed.

5. Nature of the Investigation.

The Preliminary Report of the Central Committee outlines a common basis of work for all nations represented on the Commission, and each American committee or sub-committee should of course cover carefully all points of this report relevant to its topic. Both the national and

the international aspect of the work should be constantly kept in mind.

The National Aspect. The preparation of the reports calls for a comprehensive survey of our educational system in general and of the work in mathematics in detail; for a sketch of the unparalleled activities of recent decades in the development of existent institutions and in the genesis of new ones; for an account of the modifications in the work in mathematics that have already been made and of the reforms that are still under consideration. It affords us an opportunity to take an inventory of present conditions and to weigh the proposals that have been made for the future. The spirit of the work should therefore be judicial, not legislative.

The International Aspect. Since the reports are destined for the educational public of many nations, it will be expedient to give a concise account of the salient features of our schools and the conditions under which we work, such as are usually tacitly assumed in our own discussions. Work in mathematics must be regarded and interpreted in the light of its environment, and our reports should furnish the readers of other nations with information respecting our educational system and conditions, analogous to that which we shall expect from them.

America is unique in the liberty left to individual initiative in matters of education, and in the absence of authoritative central legislation and supervision. It is desirable therefore that the reports describe clearly the practical working of this freedom and its effect, good and bad, upon our progress in general and in mathematical education.

We likewise stand alone in the complete separation of Church and State throughout our entire history, and an account of the effect of this on the work of education will be of interest to those nations that have faced or are facing serious problems in connection with religious instruction.

We are also unique in the brevity of our educational history, and in the consciousness of living in its formative epoch, a consciousness that permeates all our activities. While it is not the aim of the Commission to study educational history or to tabulate statistics, it may be necessary, under American conditions, to do some work of this nature in order to understand the present and to forecast the future.

Although the great central problems are fully stated in the Preliminary Report, we have others that are peculiar to ourselves, such as the education of the negro, and the training and Americanizing of the large number of uneducated immigrants constantly pouring in upon us.

In all of these respects, the various reports should pay suitable attention to the international character of the work.

6. Committees and Subcommittees.

The committees and subcommittees, designated respectively by Roman and Arabic numerals, and the topics to be considered by each, are as follows:

I. General Elementary Schools.

1. Kindergarten. Topics a-e.
2. Public and private schools, grades 1-6 inclusive. Topics a-d.
3. The same. Topic e.
4. Public and private schools, grades 7 and 8. Topics a-d.
5. The same. Topic e.

II. Special Kinds of Elementary Schools.

1. Trade Schools. Topics a-d.
2. Corporation industrial schools. Topics a-d.
3. Industrial classes in public schools. Topics a-d.
4. Teachers for the above. Topic e.

III. Public General Secondary Schools.

1. Boys' schools. Topics a-d.
2. Girls' schools. Topics a-d.
3. Coeducational schools in the East. Topics a-d.
4. The same in the Middle West.
5. The same in the South.
6. The same on the Pacific Slope.
7. Teachers for the above. Topic e.
8. The six-year curriculum.

IV. Private General Secondary Schools.

1. Boys' schools, including military and religious. Topics a-d.
2. Girls' schools, including religious. Topics a-d.
3. Coeducational schools. Topics a-d.
4. Teachers for the above. Topic e.

V. Normal Schools.

1. State normal schools not requiring high-school graduation for entrance. Topics a-d.
2. The same, requiring high-school graduation.
3. Private normal schools. Topics a-d.
4. Teachers for the above. Topic e.

VI. Technical Secondary Schools.

1. Public schools—manual training, industrial, nautical. Topics a-d.
2. Private and corporation schools. Topics a-d.
3. Public commercial schools. Topics a-d.
4. Private commercial schools. Topics a-d.
5. Agricultural schools. Topics a-d.
6. Teachers for the above. Topic e.

VII. Miscellaneous Types of Secondary and of Elementary Schools not included under II.

1. Evening technological and commercial schools. Topics a-e.
2. Private correspondence schools. Topics a-e.
3. Schools for licensed accountants. Topics a-e.
4. Schools for negroes and Indians. Topics a-e.
5. Schools for the blind, for cripples, for deaf mutes. Topics a-e.

VIII. GENERAL QUESTION OF PREPARING TEACHERS OF MATHEMATICS FOR PUBLIC SCHOOLS.

1. The training required for primary grades, 1-4.
2. The same for grades 5-8.
3. The same for the four-year secondary school.
4. Failures in the technique of teaching, their nature, causes, and remedies.
5. The question of securing acceptable candidates for the teaching profession. Information as to the well-being of teachers and as to the causes of unattractiveness of the work.

IX. EXAMINATIONS IN MATHEMATICS, OTHER THAN THOSE SET BY THE TEACHER FOR HIS OWN CLASS.

1. Nature of promotion in elementary schools and admission to secondary schools.
2. Entrance to college by college examinations.
3. The same by College Entrance Board examinations.
4. The same by State examinations.
5. The same by certification.
6. State and local examinations of teachers.
7. Civil service examinations.
8. All other State systems of examinations.

X. MATHEMATICAL WORK IN AMERICAN POSSESSIONS.

1. Alaska.
2. Porto Rico.
3. Hawaii.
4. Philippines.

XI. INFLUENCES TENDING TO IMPROVE THE WORK OF THE TEACHER.

1. Periodical literature.
2. Teachers' associations, including reading circles.
3. Teachers' institutes.
4. State supervision of teachers.
5. Activities of publishers and their agents.

XII. TECHNOLOGICAL SCHOOLS OF COLLEGIATE GRADE, SEPARATE OR CONNECTED WITH COLLEGES OR UNIVERSITIES.

1. Independent technological schools.
2. Technological departments in colleges and universities.

XIII. OTHER PROFESSIONAL SCHOOLS OF COLLEGIATE GRADE, SEPARATE OR CONNECTED WITH COLLEGES OR UNIVERSITIES.

1. For the training of teachers.
2. For the training of actuaries.
3. For the training of army officers, including schools for graduates of West Point.
4. For the training of naval officers, including schools for graduates of Annapolis.

XIV. Colleges of Liberal Arts, and Universities, State and Endowed, Undergraduate Work.

1. Men's colleges. Topics a-d.
2. Women's colleges. Topics a-d.
3. Coeducational colleges. Topics a-d.
4. Preparation and status of instructors.

XV. Graduate Work in Universities and in other institutions of like grade.

1. Courses of instruction.
2. Preparation for research and for the doctor's degree.
3. Administration, statistics and history of the doctor's degree.
4. Preparation and status of instructors.

XVI. General Survey.

1. The American system as a whole.
2. The work in arithmetic as a whole.
3. The same for algebra.
4. The same for geometry.
5. The same for college mathematics.
6. The same for university mathematics.

7. Methods to be followed by Committees.

It is expected that the five topics designated as a-e will be considered for each type of school and grade of work, and that each committee will examine and report upon the work as it now stands and upon the proposals for reform that are seriously considered by a sufficiently large body of teachers. The committees and subcommittees are also at liberty to incorporate new proposals for improvement in their reports, if their study of the situation leads them to formulate any that they feel should be published at this time.

The order of procedure as to reports will be as follows: Subcommittees should first prepare their reports and submit them in typewritten or printed form through their chairmen to their respective committees. The committee to which these reports are submitted should then prepare a report in typewritten or printed form based on the reports of the subcommittees and on any additional material that the committee may possess. Some initial duplication of work is unavoidable, and it is desirable in so far as it secures the independent study of important topics by different committees. The reports of the several committees and the reports of all subcommittees will then be transmitted to the Commissioners and will be utilized in the preparation of their report in the International Commission which will, in turn, use this material in its final report.

It is entirely probable that the reports of all committees and subcommittees will be incorporated in full in the report of the commissioners, or with such abbreviation as space limits may necessitate.

It is desirable that subcommittees and committees secure as full consideration of their proposed reports as possible, by individual criticism, by discussion at meetings, and by publication, and that the

results of value be utilized in the preparation of their final reports. It should be distinctly understood, however, that all such provisional reports should be described as such, and in no case as reports of or to the International Commission or results authorized by it.

8. DATES FOR SUBMITTING REPORTS.

It is hoped that all committees and subcommittees will organize and outline their work before the summer vacation of 1909, and that all subcommittees will report to their respective committees by February 1, 1910. Committee reports must reach the American Commissioners by May 1, 1910, and the American report, in its initial form, must be ready by January 1, 1911, for consideration by the International Commission.

SCIENCE QUESTIONS.

FRANKLIN T. JONES,

University School, Cleveland, Ohio.

Readers of SCHOOL SCIENCE *are invited to propose questions for solution—scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

QUESTIONS AND PROBLEMS FOR SOLUTION.

12. *Taken in substance from an East High School (Cleveland) examination paper.*

Solve the following problems without using a formula:

(*a*) What time will be required for a 45 dyne force acting on a 35 gram mass to produce a change of 18 cm. per second in the velocity?

(*b*) A stone falls from a bridge to the water below in 3½ seconds. How high is the bridge?

[NOTE: Many objections have been raised to the *mathematical* requirements for solving such physical problems as the above. Try to solve them by simple analytical methods such as are used in purely arithmetical problems in percentage and mensuration and see whether any algebraic formulas are necessary. Teachers are requested to propose problems for solution by analysis. EDITOR.]

13. *Proposed by O. R. Sheldon, Chicago, Ill.*

Why can a heavier load be drawn on a wagon with springs?

14. *Suggested by A. M. Taylor, General Chemical Co., Cleveland, Ohio.*

How much 66° acid [93.19% H_2SO_4] will be required to raise a tank which will contain 56,000 lbs. of 60° sulphuric acid to 60° [77.67% H_2SO_4], provided the stock runs 72.65% H_2SO_4?

[NOTE: This is a *practical* problem which the "boys" in an acid works solve daily with an experimental accuracy of about 2/100 of one per cent. EDITOR.]

15. *Suggested by the use of "absolute zero" in a recent syllabus of essentials in elementary physics.*

(*a*) How is zero on the absolute scale of temperature *correctly* defined?

(*b*) What is the zero of the perfect or ideal gas thermometer? Why is it so selected?

(*c*) What is the numerical relation between temperatures measured on these scales?

SOLUTIONS AND ANSWERS.

4. *Proposed by O. R. Sheldon, Chicago, Ill.*

A common kite, concave in front, will not fly. Why?

Answer by Chas. H. Korns, Bradford, Pa.

A kite lurches from side to side with the wind. If it is plane in front it moves at approximately right angles to the string and keeps it taut. If it has concave front its movements from side to side describe arcs of circles about its radius of curvature. If the length of string should be equal to or shorter than its radius of curvature I can see no reason why it should not fly, for in any side movement the string would be taut. If, however, the string should be longer than the radius of curvature, the string would become slack and the kite would be hurled to the ground.

6. *Proposed by A. Haven Smith, Seattle, Wash.*

What would be the effect of Doppler's principle applied to heat? To light?

Answer by G. B. M. Zerr, Philadelphia, Pa.

If the body radiating heat were moving toward you the intensity of the heat you receive would be increased, while if the body were moving from you, the intensity would be diminished. If the body emitting light were moving toward you all the lines of the spectrum would be displaced toward the violet end, while if the body were moving away from you, the lines would be displaced toward the red end.

7. *Proposed by O. R. Sheldon, Chicago, Ill.*

When a ship is struck by a ball fired at very high velocity, splinters are not scattered. Why?

Answer by the proposer.

The ball cuts through the wood so fast that the splinters do not have time to extend. The more rapidly they are forced to curve, the greater the tendency to break near the application of the force.

CREDIT FOR SOLUTIONS RECEIVED.

3. Annie Cloyd, Muscatine, Iowa. Previously reported, 8 solutions. (9)
4. Chas. H. Korns, G. B. M. Zerr, O. R. Sheldon. (3)
6. G. B. M. Zerr. (1)
7. O. R. Sheldon, G. B. M. Zerr. (2)
8. G. B. M. Zerr. (1)

REAL APPLIED PROBLEMS IN ALGEBRA AND GEOMETRY

COMMITTEE ON INVESTIGATION: JAMES F. MILLIS, *Chairman, Francis W. Parker School, Chicago;* JOS. V. COLLINS, *State Normal School, Stevens Point, Wis.;* C. I. PALMER, *Armour Institute of Technology, Chicago;* E. FISKE ALLEN, *Teachers College, New York, N. Y.;* A. A. DODD, *Manual Training High School, Kansas City, Mo.*

Teachers of mathematics and others who are interested in the movement to reform the teaching of mathematics in the secondary schools by teaching the subjects more in relation to their practical uses are earnestly requested to coöperate with this committee.

All real applied problems of algebra or geometry that are sent to the members of the committee will be printed in these columns, and proper credit given the contributors.

Teachers are requested to try these problems in their classes, and to forward criticisms of them to the committee.

Problems.

By E. Fiske Allen, Teachers College, New York.

1. In setting stakes for a house foundation, after the front line was staked, a distance of 8 ft. was measured from the corner along the front, a pole 6 ft. long was held with one end at the corner and a pole 10 ft. long with one end at the end of the 8 ft. length. The other ends of the poles were swung together, thus giving a square corner. Why?

2. To irrigate a 20-acre field, water is run full bore through a six-inch pipe with a velocity of 1 ft. per second. How long will it take to deliver one inch of water over the field?

3. Two hay-stacks of the same shape were measured to the bulge, the first measuring 8 ft. and the second 12 ft. The smaller is hauled away and weighed, the weight being 2½ tons. What would be the weight of the larger?

By Elwell F. Kimball, English High School, Lynn, Mass.

4. A mason wishes to arch a cistern that has a circular opening of 18 ft. in diameter. The arch is to be spherical in shape, with a rise of 5 ft., and the bricks are laid flatwise in 2 circular courses, forming an 8¼ inch wall. In order to obtain the spherical surface the joint is wedge shaped in section, starting at the inner surface about ⅛ inch thick. How many bricks 8 by 4 by 2 inches are needed and how much lime, allowing 1 cask to 1,000 bricks? Add 3 per cent for waste of brick due to cutting.

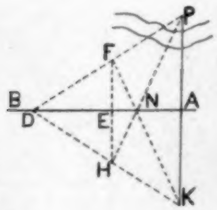
5. The engineer's plan shows a canal, trapezoidal in section with a depth of 8 ft., a width at base of 5 ft., and sides with slope of 1 to 1. A contractor bidding on the job learns that the soil is soft loam and that the mean haul is 1,000 ft. From past experience he estimates that it will cost him 28½ cents per cubic yard to pick, spade, and remove as required. If the canal is 872 ft. long, what will the contractor estimate to be the total cost for the job? Allowing 10 per cent of the cost for profit, what will be his bid?

By Miss Mabel Sykes, South Chicago High School.

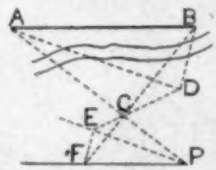
(From an article by Miss Sykes in School Science and Mathematics, May, 1906.)

6. Calculation of irregular areas. When areas are calculated by offsets, it is sometimes possible to place these offsets at regular intervals. The following rule is given: "To the half sum of the initial and final offsets add the sum of all the intermediate offsets and multiply the sum by the common distance between offsets." Give proof of the rule.

7. In surveying, to determine a line from the inaccessible point P perpendicular to AB. Lay off FE perpendicular to AB at an arbitrary point and of any length. Make EH = EF. Point D is obtained in lines PF and AB; next point N in HP and AB; next K in DH and FN. PK is perpendicular to AB. Why?

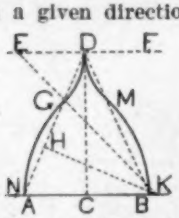


8. In surveying, to run a line through a given point P and parallel to an inaccessible line AB. Take C any point in AP, and D any convenient point. Get line AD; PE parallel to AD, cutting DC at E; EF parallel to BD, cutting BC at F. PF is parallel to AB. Why?



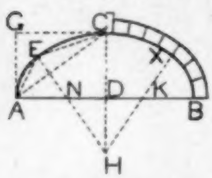
9. Show how to cut from a piece of land a triangular field of given area, by a line running through a given point.

10. Show how to cut from a piece of land a triangular field of given area, by a line running in a given direction.



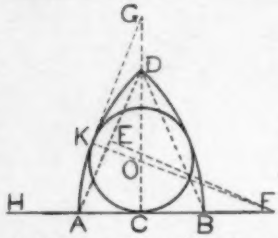
11. The Persian Arch. Given AB the span and CD the altitude. Draw the isosceles triangle ADB. Divide AD into three equal parts. Draw HK the perpendicular at the first point of division, cutting AB at K. Draw KG (G the second point of division) cutting EF at E. EF is parallel to AB through D. K is center and KA radius and E center and ED radius for arcs AGD. On right side of figure FD equals DE, and AN equals BK, and the arcs drawn. Question: Why do the arcs meet at G and M? (From Hanstein's Constructive Drawing.)

12. Segmental Arches. Given AB the span and CD the altitude. DC is perpendicular at center of span. Complete the rectangle GADC. Draw diagonal AC. Bisect angles GAC and GCA. Bisectors meet at E. Draw EH perpendicular to AC, meeting AB at N and CD produced at H. Make DK equal to DN. N is center and NA radius, H center and HE radius, and K center and KB radius for arcs. Question: Why will arcs pass through E, X, and C? (From Hanstein's Constructive Drawing.)

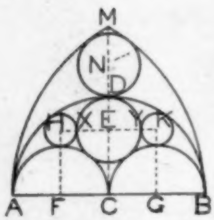


13. The Gothic Arch and the inscribed circle. Given AB the span

and DC the altitude, perpendicular at center of AB. Complete the isosceles triangle ADB. Draw EF perpendicular bisector of AD. Make AH equal to BF. F is center and FA the radius and H center and HB radius for sides of the arch. Make CG equal to AF and GK equal to CF. Draw KF cutting DC at O. O is center and OC radius of circle. Questions: Why do arcs meet at D and why is circle tangent to AB and to the two arcs? Also, what must be the relative lengths of the span and the altitude in the Gothic arch? This construction is interesting in connection with the locus of centers of all circles tangent to two given equal circles. (Construction from Hanstein's Constructive Drawing.)

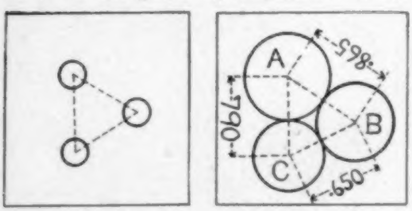


14. Tracery windows. Given diameter AB of the semicircle ADB. AB is divided into four equal parts, and DC into three. HK is perpendicular to DC at E, the second point of division, and HF and KG perpendicular to AB. DN equals DE. F is center and FC radius, G center and GC radius, E center and ED radius, H center and HX radius, K center and KY radius, N center and ND radius, and A and B centers and AB radius, for the various arcs and circles. Questions enough will be found to occupy a class for some time. The arcs and circles whose centers are C, G, F, and E are frequently used in church windows. (Construction from Hanstein's Constructive Drawing.)



By J. F. Millis, Francis W. Parker School, Chicago.

15. In accurate tool work where holes are to be bored close together in a metal plate by means of a lathe, the centers of the holes are first marked carefully to thousandths of an inch. This may be done by first turning on the lathe discs such that when placed tangent to each other their centers mark the positions of the centers of the required holes. These circular discs are then fastened on the metal plate in tangent positions, and the holes bored at their centers. Thus, to bore three holes the distances between whose centers shall be .650′, .790′, and .865′, respectively, the sizes of the discs A, B, and C are determined as follows: Compute the radii of three tangent circles whose center lines are these distances. Let them be x, y, and z.

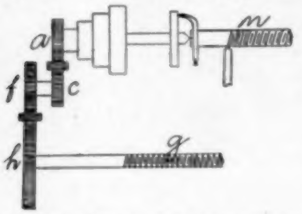


Then $x+y=.650'$, $x+z=.790'$, $y+z=.865'$.

Solve this system of equations, and find the radii of the discs.

16. "Change gears" for cutting threads on screws. In the simple geared lathe, n is rod on which threads are being cut, g is "lead screw" of known pitch which carries the cutter sidewise to cut the threads. a, c, f, h, are cog wheels the dimensions of which can be made such

that the threads n can be cut any desired number to the inch. "Change gears" f and h can be removed and replaced by wheels of different number of teeth. The relation between the pitches of the screws and the sizes of the wheels is given by the formula



$$n = \frac{gch}{af},$$

where n = number threads to inch to be cut, g = number threads to inch of lead screw, c = number teeth in gear c, h = number teeth on change gear h, f = number teeth on change gear f, and a = number teeth on spindle gear a.

Solve this formula for h/f. Since g, c, and a are known on the machine, it is thus possible to determine the combination of wheels h and f necessary to cut any number of threads n to the inch.

If $g = 5$, $a = 25$, $c = 48$, $f = 48$, $h = 60$, find n.

By Wm. H. Friedman, Teachers College, New York.

17. In an electrical circuit connected in parallel, the resistance of one branch is 4 ohms, of the second branch 8 ohms. Find the resistance of the circuit. Use equation $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$, where R = resistance of whole circuit, R_1 = resistance of one branch, and R_2 = resistance of other branch.

18. If the masses of two bodies are m_1 and m_2, respectively; s_1 and s_2 their specific heats; t_1 and t_3 their temperatures; then if they are mixed together, the temperature t_2 of the mixture may be found from the equation $m_1\, s_1\, (t_1 - t_2) = m_2\, s_2\, (t_2 - t_3)$.

1 lb. water ($s = 1$) temp. 75° was mixed with 5 lb. water temp. 25°. Find the resulting temperature.

19. The resistance of an electrical battery and the external wire equal 1.5 ohms. By doubling the length of the external wire, it was found that the total resistance was 2 ohms. Find the internal resistance of the battery.

20. In an athletic meet, team A won the championship with a total of 33 points, made up as shown in the following table. Team B got second place with a total of 25 points, and team C third place with a total of 23 points. How many points does each place count?

Team	1sts	2nds	3rds	Total Score
A	5	2	2	33
B	3	3	1	25
C	1	4	6	23

A NEW ROTARY MICROTOME.

There are doubtless many laboratories where the perfection of the Minot Automatic Rotary Microtome, made by the Bausch & Lomb Optical Company of Rochester, N. Y., is admired, but the price of the instrument has prevented them from adding it to their equipment in spite of their desire to have the benefit of the work possible with it. Such laboratories will, we believe, be glad to know that the same company now offers a simplified Rotary microtome which has much in its favor, even as an auxiliary in laboratories now using the Automatic Rotary. The same principles of construction have been followed in the simplified type, the simplification having been carried out as regards adjustments principally.

The feed in the new instrument ranges from 0 to 26 microns in steps of 2 microns, and is of the cam feed type. The micrometer wheel is provided with a simple handle which is used when adjusting the object with reference to the knife and for returning the object carrier to the initial position after the screw has been fed out. The object is adjustable in three planes and is attached either by cementing it to one of the three discs supplied with the microtome, or an object clamp may be used. The knife block is adjustable to and from the object, and the knife may be tilted by adjusting opposing screws.

PERSONALS.

Mr. John C. Stone for nine years professor of mathematics in the State Normal College, Ypsilanti, Mich., has tendered his resignation in order to accept the position as head of the department of mathematics in the new normal school at Montclair, N. J.

Mr. Dana W. Hall, who for many years has been connected with the college and high school departments of the publishing house of Ginn and Company, was on February 1, 1909, admitted to membership in the firm.

Albert B. Porter of the Scientific Shop, Chicago, died, April 16, aged forty-three. He was a graduate of Purdue and Johns Hopkins Universities. For several years he was professor of physics at Armour Institute, Chicago. More recently he was engaged in the manufacture and importation of scientific apparatus.

NEWS ITEM.

The following gentlemen have accepted positions on the American Advisory Council of the International Commission on the Teaching of Mathematics (see page 603). Professor Maxime Bocher, Commissioner Elmer Ellsworth Brown, President Nicholas Murray Butler, Professor Thomas Scott Fiske, Dr. G. W. Hill, President Harry Pratt Judson, President A. Lawrence Lowell, Emory McClintock, Esq., Professor E. H. Moore, Professor Simon Newcomb, Professor Harry W. Tyler, Professor J. H. Van Amringe, Professor Henry Seely White, President R. S. Woodward.

FOSSILS OF THE CANEY SHALE.

Studies by the Geological Survey.

The baffling nature of some of the problems with which geologists have to deal is well illustrated by certain conditions existing in Oklahoma, where the Arbuckle and Ouachita mountains, though in sight of each other, contain rocks whose sequence radically differs. Two great formations in the Ouachita Mountains, aggregating more than 10,000 feet in thickness, seem to have entirely disappeared before reaching the Arbuckle Mountains. That is to say, while 10,000 feet of sand and mud were settling from the turbid waters of some vanished sea which stood where the Ouachita Mountains now rise, the Arbuckle area, only a few miles distant, was receiving no sediments at all; or if the area was receiving sediments they have been removed without leaving a trace. It is even difficult to determine the position in the Arbuckle strata which these missing beds would have occupied if they had been deposited there. The singularity of this occurrence will be best understood when it is recalled that this accumulation of sediments represents a mass far higher than any mountains east of the Rockies.

The latest contribution to the study of this region has just been issued by the United States Geological Survey as Bulletin 377, under the title "The Fauna of the Caney Shale," by George H. Girty. Mr. Girty has investigated the fossils that have been obtained in the Caney shale, which occurs in both these groups of mountains, and draws certain conclusions as to the position in the Arbuckle Mountains which would be occupied by the formations that are absent there but present in the Ouachita Mountains. The Caney shale has this peculiarity—its lower portion contains in certain areas huge boulders, clearly derived from older strata and brought there when the shale was soft mud. The only known agency that could transport such masses of rock is moving ice, and these boulders seem to indicate that there may have been another ice age on this continent, long preceding that which so plainly left its marks on the northern part of America.

The region discussed by Mr. Girty is of so great interest that all investigations regarding it are important to the geologist, to whom the paper will be of greatest value.—*U. S. Geol. Survey.*

PLASTER OF PARIS WORKS—REPORT ON EXCURSION TO.

Ben M. Jaquish, Secretary.

The gypsum, from which Plaster of Paris is made at the works of the Newark Lime and Cement Manufacturing Company, is obtained from Nova Scotia. There part is mined and the rest obtained from an open quarry. It is brought to Newark by boat and unloaded at a wharf belonging to the company. As it reaches the mill it is in lumps of varying sizes, some of them weighing 100 lbs. The gypsum seen here illustrates all the varieties, but most of it is granular and compact, white, pink, gray, or blue. Some of it is beautifully banded or color stratified. There is also a large amount of selenite and a large amount of alabaster.

The gypsum before grinding is sorted, and different grades of Plaster of Paris are made. After sorting, the lumps are crushed in a Blake jaw crusher to 2″ size. The product of this crusher is fed to a reducer of the coffee mill type, and the product of this pulverized by mill-stones; 50% of that which passes the stones will pass through a 100-mesh sieve.

The calcining is done in kettles. These kettles, of which there are six, are 10 ft. in diameter and 8 ft. high, cylindrical in form, and made of boiler iron ⅜″ thick. The bottom, curved upward, is of cast iron. The kettle is built over a fireplace and is surrounded by a circular brick wall, leaving a space which is used as a part of the furnace flue. Each of the kettles has four circular flues 12″ in diameter, running horizontally through the kettles near the bottom. In this way the hot flue gases pass all around and through the kettles, thus heating the contents uniformly. The top of the kettle is covered with a sheet iron plate with two openings, one for escape of steam and the other for charging. The kettles hold about ten tons and require from two to three hours to calcine properly. Near the bottom on the side is an opening for discharging the calcined product. It is necessary to keep the contents of the kettle constantly stirred, and this is done by means of horizontal paddles attached to a vertical shaft. The temperature is determined by thermometers and is kept at about 340°F. Some Plaster of Paris is carried off with the escaping steam and is recovered in settling chambers. After the calcining is completed, the hot material is run into a fireproof pit. From here it is carried by metal elevators to a revolving copper wire mesh cylindrical screen and the coarse screenings (1 to 2%) reground in mill stones. From the screens the material goes to a storage house, where it is packed in bags or barrels for shipment.

THE SHAW SCHOOL OF BOTANY.

The recently issued administrative report of the Missouri Botanical Garden, and an announcement of Washington University concerning the Henry Shaw School of Botany, indicate that the Shaw foundation is on the eve of entering on a much increased activity. Although Henry Shaw in 1885 endowed a school of botany in Washington University, to the head of which Professor Trelease was called from the University of Wisconsin, the provision made was practically for only a chair of botany. Four years later, on the death of Mr. Shaw, his fortune, appraised at several million dollars, passed to the care of trustees, for the maintenance of his long-established and well-known garden and the further development of an institution of research and instruction in botany and allied sciences, the head of the School of Botany being selected as its director.

In the twenty years that have since passed, the trustees of the Shaw estate have been compelled to administer their trust on a maintenance basis, seeing approximately a quarter of their gross income absorbed in general taxes and nearly as much more claimed for street improvements, sewers and similar purposes, a large part of which

were entailed by the possession of extensive tracts of unimproved real estate within the city limits. Meantime, the revenue of the School of Botany has sufficed for scarcely more than meeting the undergraduate needs of the University. Nevertheless, maintenance of the Garden has been made to include the provision of a good equipment in living plants (11,464 forms), herbarium (618,872 specimens), and library (58,538 books and pamphlets). A part of the time of otherwise indispensable employees has been given to botanical investigation, the results of which are published in a series of annual reports begun in 1890; and fifteen graduate degrees have been earned in the School of Botany.

Though a continuation of high special taxes is anticipated for the next few years, the trustees of the Garden hope to see the end of this burden before a great while, and in coöperation with the University authorities they are now prepared to make larger research use of the equipment on hand and begin to provide for graduate instruction to a greater extent than has been possible heretofore. Last year a well-designed fireproof building of about 12,000 square feet of floor space was erected. A part of this is being furnished in steel for stack purposes, and the remaining—and larger—part is being equipped for laboratory use. It is now announced that a definite step toward the fuller development contemplated by the founder and planned by the director has been taken in the establishment of the post of plant physiologist at the Garden, and the creation of a professorship of plant physiology and applied botany in the Shaw School of Botany, with provision for two research fellowships in botany—in addition to the Engelmann professorship held by Dr. Trelease, the assistant professorship held by Dr. Coulter, a teaching fellowship to which Mr. C. D. Learn has recently been appointed, and the honorary post of plant pathologist at the Garden held by Dr. von Schrenk.

With this equipment and staff, which are to be gradually increased and are likely to be much enlarged in the near future, it is intended to develop research and graduate instruction and to establish in the broadest sense a course in applied botany, in addition to giving the undergraduate instruction needed in Washington University.

To the new professorship, Dr. George T. Moore has been called, as possessing to an unusual extent the desired combination of established reputation, breadth of view and expert appreciation of the economic applications of botany. The research fellowships are open to capable graduate students, and are believed to offer unusual opportunities for the productive use of talent in investigation. The library, herbarium, and garden furnish the necessary facilities for the most advanced investigation, and the work in the School of Botany is to be so planned that the individual needs of students engaging in research will be met in every way possible, while leading to the customary degrees.

ONTARIO MATHEMATICAL AND PHYSICAL ASSOCIATION.

The annual meeting of the Mathematical and Physical Section of the Ontario Educational Association was held April 13 and 14 in the University of Toronto.

The following program was carried out:

Report of Text-book Committee.

President's Address, "A Study after the Manner of Plato," Mr. Wilson Taylor, Chatham Coll. Inst.

Paper, "Mathematical Fallacies," Mr. T. Kennedy, N. W. High School, Toronto.

Discussion, "Entrance to Normal School Algebra Paper of 1908," led by R. Wightman, Harbord St. Coll. Inst., Toronto.

Address, "A View of Education as Applied to Geometry," Prof. Matheson, Queen's University, Kingston.

The following were elected officers for 1909-10:

Hon. President, W. Taylor, Chatham Coll. Inst.

President, J. D. Dickson, Niagara Falls Coll. Inst.

Vice-president, Jno. Elliott, Bowmanville High School.

Sec'y-Treas., T. Kennedy, N. W. High School, Toronto.

Councillors, J. T. Crawford, W. W. Nichol, J. S. Wren, E. T. Seaton, L. W. Sprung.

H. T. R.

SOUTHERN CALIFORNIA SCIENCE ASSOCIATION.

The second general meeting of this Association was held at the University of Southern California, Los Angeles, on Saturday, April 24. It proved to be one of great interest and most successful in point of attendance.

The program for the morning session included two musical numbers by Prof. W. R. Bowker, the invocation offered by the Rev. E. J. Inwood, and an address of welcome by Prof. F. E. Owen, in the place of President Bovard, who had been called from the city. Rev. Matt S. Hughes of the First Methodist Church, Pasadena, delivered the principal address of the meeting, his subject being, "Pulpit and Laboratory." This was a most interesting presentation of what scientific method and laboratory instruction had brought to the speaker. In concluding his address, he stated that there seemed only one thing that a man, as minister, can do in these present days; when truth comes from any direction to accept it and give God thanks.

Opportunity presenting, a short business session was held before adjournment for luncheon.

The afternoon session was devoted to the consideration of "Accessories to Successful Science Teaching," from the standpoint of Chemistry, Physics, Physical Geography, and Biology.

At the close of the program, the business session was resumed. The principal matter of business was the adoption of a revised constitution, which, when ratified by the Southern California Association of Mathematics Teachers, will make operative a merger of the two associations under the name of the Southern California Science and Mathematics Association.

The committee on bibliography reported progress in collecting data on the scientific periodicals available in our territory, and the committee on the general science course is at present working on a preliminary statement to form the basis for a more detailed consideration of such a course.

Six applications for memberhip were acted upon favorably, making a total of about fifty.

H. T. CLIFTON, Sec'y, Pasadena, Cal.

REPORT OF MEETING OF THE NORTHEASTERN OHIO ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

(Affiliated with Central Association).

On April 24 a meeting of this association was held in the new Technical High School at Cleveland, O., the use of which was generously granted us by Principal James F. Barker. The morning session, presided over by President Philip E. Graber of South High School, Cleveland, was devoted principally to three excellent papers.

1. "The Relation of Reading to Science and Mathematics," presented by Mr. D. C. Rybolt, Principal of Akron High School, in which was shown the great importance of real reading when pupils are preparing lessons in almost any subject.

2. "Grammar School Arithmetic," presented by Mr. William H. Elson, superintendent of Cleveland schools.

In this paper Mr. Elson discussed the amount of time spent by pupils in the fundamental studies, the newest methods of teaching arithmetic in the grades, and the better results obtained now.

3. "Benefits of High School Visitation," by Professor George R. Twiss, High School Inspector for Ohio State University. In this discussion Mr. Twiss pointed out the great benefits he had derived, and those which schools and teachers had derived from his visits and his frank criticisms or commendation of existing conditions.

After a good dinner, served in the school dining room, Principal Barker conducted a tour of inspection a mile and a quarter in length through the wonderful $500,000 Technical High School which was completed last fall and is now in use day and night.

The principal address of the afternoon session was delivered by Professor H. E. Slaught of the University of Chicago, entitled "The Humanizing of High School Mathematics." It was a splendid paper helping us all to see the general faults of most mathematics teachers and at the same time showing us how to do better and more helpful work with our pupils.

In the Science Section a paper was read by Miss Nellie Canfield of Central High School, Cleveland, entitled, "Should There be a Course in Physics especially for Girls?"

In the Mathematics Section Miss Ethel Sowers of Central High School discussed the Algebra Report submitted to Central Association at Chicago in November, 1908. Ralph A. Brown, Secretary.

INDIANA ASSOCIATION.

The Indiana Association of Science and Mathematics Teachers met in Shortridge High School, Indianapolis, April 2. The sectional meetings were held first, followed by the general meeting.

Vice-president M. B. Thomas of Wabash College presided at the general meeting. Mr. Arthur Foley, Professor of Physics, Indiana University, gave an exceedingly interesting illustrated lecture on the subject of "European Laboratories."

The following officers were elected for the ensuing year:

President, W. W. Hart, Shortridge High School, Indianapolis; Vice-president, H. S. Voorhees, Fort Wayne High School; Secretary-Treasurer, Henry F. A. Meier, Muncie High School; Chairman Executive Committee, F. S. Lamar, Richmond High School.

Mr. E. E. Ramsey, principal Bloomington High School, presided at the Botany, Zoölogy, and Physiography section, and the following program was presented:

I. "The Ground Plan of Geographical Battlefields," Mr. Chester Zechiel, Anderson High School.

II. "Coöperation between the High School Teacher of Botany and the State Entomologist," Mr. Benj. Douglass, Indiana State Entomologist.

III. "Report of Committee on a Course of Study in Botany," Prof. M. B. Thomas, Wabash College.

Prof. Erwin Ferry, Purdue University, presided at the Physics and Chemistry section and the program was as follows:

I. "A Series of Experiments in Electrolysis and their Place in Secondary Chemistry" (with demonstrations), Mr. Walter Baker, Shortridge High School, Indianapolis.

II. "The Teaching of Heat in Physics," by Mr. H. M. Ibison, Marion High School; Mr. Jerome Isenberger, Lebanon High School, and Mr. R. T. Ratliff, Central Normal College, Danville.

At the Mathematics section, Prof. D. A. Rathrock, Indiana University, presided, and the following program was presented:

I. "The New Course of Study in Mathematics for Commissioned High Schools of Indiana."

Discussion by Prof. T. G. Alford, Purdue University; Mrs. Martha Ivins, Muncie High School, and Mr. Raymond Modesitt, Bloomington High School.

II. "The Conscious Use of Analysis in Geometry," by Walter Woodhams, Shortridge High School.

III. General discussion.

HENRY F. A. MEIER.

The mathematics teachers belonging to the Central Kansas Teachers' Association met at Hutchinson, April 1, and organized into a Mathematics Teachers' Section. A round table was held. The papers were good. General discussions were lively and to the point. Supt. Shirk gave a talk on the value of permanent organizations and the value of SCHOOL SCIENCE AND MATHEMATICS for mathematic teachers.

The officers for next year are: Pres., Miss Eleanor Harris, Hutchinson; Sec., Miss Rosalia R. Stone, Great Bend; Treas., Ralph Williams, Sterling.

ASSOCIATION OF KENTUCKY COLLEGES.

The Mathematics Section of the Association of Kentucky Colleges held an enjoyable and profitable session at State University at Lexington on Saturday, April 24. This Section was tentatively organized in January at the regular meeting of the Association held at Transylvania University. The temporary chairman elected in January, Professor A. L. Rhoton of Georgetown College, took up the work with energy and arranged a program which was carried out in full, as follows:

I. "Mathematics Course of Study for Kentucky High Schools," Henry Lloyd of Transylvania University; J. Leslie Purdon of State University.

II. "Mathematics for Last Half of Fourth Year High School," A. L. Rhoton of Georgetown College.

III. "College Entrance Requirements," Jas. G. White of State University, C. G. Crooks of Central University.

IV. "What Should Constitute the Freshman Year's Work?" Miss Josephine A. Robinson of Berea College.

V. "The Minimum Amount of Work Which Should be Required in any College Course," W. H. Garnett of Kentucky Wesleyan College.

A permanent organization was effected and the following constitution was adopted:

The name of this organization shall be the "Mathematics Section of the Association of Kentucky Colleges." Officers: President and secretary elected annually at the April meeting. No person shall hold the office of president two years in succession. Meetings: Regular meetings to be on the last Saturday in April of each year at one of the colleges of the association, and a brief conference at the time and place of the College Association. Membership: All teachers of mathematics in the colleges connected with the College Association are members.

Professor A. L. Rhoton of Georgetown was elected president and Professor Josephine A. Robinson of Berea secretary for the ensuing year. A committee was appointed to confer with the State Superintendent of Public Instruction and to devise ways and means to improve instruction in mathematics in the High Schools of the State.

At the close of the session the members of the section were entertained at an elegant and bountiful luncheon at the Phoenix Hotel by the hosts of the day, the teachers of mathematics in the State University. The following were present at the meeting of the Section: Professors Rucker and Rhoton of Georgetown; White, Davis, Reece, Purdom, and Downing of State University; Lloyd of Transylvania, Crooks of Danville, Garnett of Kentucky Wesleyan, and Robinson of Berea.

JOSEPHINE A. ROBINSON.

Mathematics Teachers in Private Schools are asked to assist the International Commission on Secondary Mathematics—whose work was outlined in the February number of SCHOOL SCIENCE AND MATHEMATICS—by sending their addresses, together with printed matter descriptive of their schools and courses of study, to William E. Stark, Ethical Culture School, 33 Central Park West, New York City.

COAL FIELDS OF SOUTHERN UTAH.

Report by the Geological Survey.

The existence of coal beds of workable thickness in the southern part of Utah has been known since the country was settled by the Mormons in the middle of the last century, but the isolation of the region has prevented development and less is known of the coal fields of southern Utah than of any others in the United States. Only a few small mines have been opened in the vicinity of settlements near the coal outcrops, and practically the entire region is unprospected. The completion of the San Pedro, Los Angeles and Salt Lake Railroad, however, has aroused interest in this area, and although the railroad is 40 miles from the nearest coal, a branch line could easily be constructed across the Escalante Desert between Lund and Cedar City.

Very little has been published concerning the coal of southern Utah, and no systematic study was undertaken until 1906, when Willis T. Lee, of the United States Geological Survey, made a preliminary examination of the deposits in Iron County. In the summer of 1907 a party under George B. Richardson, of the Survey, examined the Harmony, Colob, and Kanab fields in eastern Iron and Washington counties and western Kane County. Mr. Richardson's report on this area has just been issued by the Survey as a chapter in Bulletin 341-C, the publication of which has been much delayed by a fire at the engraver's which destroyed the maps illustrating it.—*U. S. Geol. Survey.*

TO REMOVE FIXED STOPPERS.

In the *Scientific American* for January 2, 1909, Mr. Randolph Bolling suggests that the bottles be inverted in a mixture of crushed ice and calcium chlorid crystals, taking care that the freezing solution does not touch the lips of the bottles. After standing twenty minutes each stopper was removed without the slightest exertion. This is the neatest and safest way to remove stoppers from bromine bottles and other corrosive chemicals. A. L. S.

ARTESIAN WATERS OF FLORIDA.

New Map of the State in Preparation.

Few people who travel through Florida realize the range of altitude in the State. Between Jacksonville and Gainesville the country appears so level and unbroken that the traveler may be excused for believing that the State is perfectly flat except where it is cut into by streams like the St. John's and the Santa Fe. As flowing artesian wells are abundant along the east coast many believe that by drilling deep enough they can also be obtained in the center of the State, but this is not true. Notwithstanding its flat appearance, the land rises from elevations near sea level at Jacksonville to 210 feet above it at Highland, and the greater part of central Florida ranges from 50 to 200 feet above tide; and even as far south as Lakeland there are a few points above 200 feet. In northwestern Florida the altitude in places reaches nearly 300 feet, and the hills in this part of the State make the elevations more apparent to the eye.—*U. S. Geol. Survey.*

BOOKS RECEIVED.

AMERICAN BOOK COMPANY.

The Human Body and Health, an elementary text-book of essential anatomy, applied physiology, and practical hygiene for schools, by Alvin Davison. 1908. Pp. 320.

New Laboratory Manual of Physics, by S. E. Coleman. 1908. Pp. 264.

Elements of Physics, by Geo. A. Hoadley. 1908. Pp. 464.

An Introduction to Practical Mathematics, by F. M. Saxelby. 1908. Pp. 220. Longmans, Green & Co., New York and London.

Human Physiology, an elementary text-book of anatomy, physiology, and hygiene, by John W. Ritchie. 1909. Pp. 362. World Book Co., Yonkers, N. Y.

History of Common School Education, an outline sketch by Lewis F. Anderson. 1909. Pp. 308. Henry Holt & Co., New York. Price, $1.25.

The Teaching of Arithmetic, by Alva W. Stamper, State Normal School, Chico, Cal. 1909. Pp. 80.

Lesson Plans in Arithmetic, by Alva W. Stamper. 1909. Pp. 17.

Physics for Secondary Schools, by Charles F. Adams, Central High School, Detroit, Michigan. 490 pages. American Book Company, Chicago.

Physical and Chemical Apparatus. 18 × 26 cm. 392 pages. Very complete. See page 489, May issue. Central Scientific Company, Chicago.

Electrical Apparatus, 11 × 17 cm. 111 pages; Mechanical Apparatus, 11 × 17 cm. 138 pages; Optical Apparatus, 11 × 17 cm. 17 pages. W. & L. E. Gurley, Troy, N. Y.

BOOK REVIEWS.

Notes on Blow Pipe Analysis, by Nicholas Knight. 16 pages. Published by the Cornell College Book Department.

Blow-pipe tests are given for the common bases and acids, and the wet tests for the common inorganic and organic acids. The work is conveniently arranged and is a suitable introduction to qualitative analysis. Adapted to use toward the end of the first year's work.

C. M. T.

Notes on the Teaching of Elementary Chemistry, with a sequence of experiments on air and combustion. Teacher's Edition. By J. B. Russell, B.Sc. (Lond.) London, 1907, John Murray, publisher. Price, 2/6.

This book of 104 pages is intended primarily for teacher's use. It deals with some points of difficulty in the teaching of elementary chemistry and then illustrates the proposed method of teaching by a sequence of experiments on the chemistry of air (part II of the preceding book.) A. L. S.

Control of the Body and Mind. Book Five of the Gulick Hygiene Series, by Frances Gulick Jewett. Ginn & Company, Boston, 1908.

Some teachers of physiology in high schools believe the subject of the special senses to be so difficult that they omit practically all consid-

eration of it in their teaching. The reason for this evidently is to be found in the very technical exposition of the senses in the usual textbook.

One of the fine things about Book Five of the Gulick Series is the scientific evidence that the author has presented fresh from the experimental laboratory and fresh from life. The dramatic interest the live investigator has in his work is conveyed in large measure to the book. The language being simple, a child who can think at all can see the proof of the need of bodily control and training. Not only that, but the good advice, inferred rather than expressed dogmatically, comes with a stimulus to do the right thing willingly and cheerfully.

H. R. L.

Problems and Questions on Plane Geometry (630), on Solid Geometry (514), on Trigonometry and Logarithms (530), compiled from recent college entrance examinations by Franklin T. Jones, University School, Cleveland, O. 40 cents each.

The compiler gives the following reasons for selecting questions from college entrance examinations only: "First, the questions themselves represent the only real standard of what a student should *know* if he is prepared for college. Second, even a superficial examination of the questions shows that they come surprisingly close to representing what he should know *whether he is going to college or not.* Third, they lack the bias of an individual. Fourth, they carry an authority lacking in questions from other sources and hence receive much closer attention. Fifth, they present a definite problem whose solution gives the student confidence in his ability to *do things.* Sixth, if he can answer these questions, he knows that he has *mastered* a certain small portion of the field of knowledge." Undoubtedly these pamphlets will be of great service to teachers who are compelled to conform their instruction to college entrance requirements.

H. E. C.

Gray Lady and the Birds, by Mabel Osgood Wright. The Macmillan Company, New York, 1907.

In "Gray Lady and the Birds" Mrs. Wright continues her active campaign against the destruction of our economic friends, by attracting children to her point of view.

The light and happiness that Gray Lady and her little invalid daughter brought to the small New England country school render insignificant by contrast the good the regular teacher herself was supposed to be doing through her formal subjects. Gray Lady and all others who make the study of nature palatable and attractive appear to succeed best when they put a little of nature's freedom into their teachings. Unfortunately, however, for the new "environment" teaching, there are so many other things that must be taught that Gray Lady and her fellow teachers feel the impulse to attempt to give the children all there is to be said, about birds, for example, before another set of teachers draws them away. If the periods of childhood and youth could be made continuously receptive, easily and naturally, of all useful knowledge from the environment, neither the rapid transit auditors of real school life nor the little friends of Gray Lady would run the risk of overmuch information.

H. R. L.

Notes on Elementary Chemistry. Part I, Preliminary Experiments; Part II, Air and Combustion, by J. B. Russell, B.Sc. (Lond.). London, 1908, John Murray, publisher. Price, 2/6.

Under the above title has appeared a set of loose leaf notes and cover for pupils' use. The various sections of the book are divided into directions for the experiments to be performed by the pupil, then a summary and extension with further demonstrations, etc., by the instructor. It is suggested that the printed pages or sections, as the case may be, can be given out before or after the pupil has completed the laboratory work at the discretion of the instructor. Advantages mentioned by the author for this scheme are:

(1) The difficulty that a book may forestall the laboratory work is overcome.

(2) The printed sections or chapters can be given out before or after the practical work.

(3) The book is built up as the course proceeds.

(4) Records of additional experiments suggested by the class, and of minor investigations branching off from the main line of sequence, can be filed in the right place.

Part I contains exercises on measurement of volume; weighing; manipulation of glass tubing, corks, etc.; relative density; the Bunsen burner; some effects of heat on substances; quantitative experiments with lead nitrate, red lead, and tin; the thermometer; solution and solubility; crystallization.

Part II: Burning of metals in air, burning of phosphorus in the air, burning of a candle in air.

The experiments have been arranged with care and the points brought out in the summary and extension at the end of a topic are helpful. A. L. S.

Physics for Secondary Schools, by Charles F. Adams, Head of the Department of Physics, Detroit Central High School. 8 vo., 490 pages. Price, $1.25. American Book Company, 1908.

Those who have known the work of Mr. Adams in the Central High School of Detroit and are familiar with his "Physics Laboratory Manual," have had high expectations of his "Physics for Secondary Schools," and they will not be disappointed.

It is the outgrowth of his many years' experience in teaching physics to boys and girls, and consequently is in a clear, direct style, the subject being presented with such "simplicity, clearness of expression, and fullness of illustration that the average secondary school pupil will readily comprehend it."

Definitions and laws are printed in italics and generally precede the explanations and illustrations; included with the latter are numerous helpful lecture experiments: these are carefully described and illustrated; some of them are new to secondary school texts. No laboratory experiments are found in the text, the author properly contending that the place for these is the laboratory manual.

The drawings and diagrams number 348. These illustrate lecture experiments, physical principles, and their practical applications. They

are well executed and their selection shows excellent judgment in choosing illustrative material.

Over five hundred problems are given, sufficient to permit the teacher latitude of choice. They have been carefully selected with reference to emphasizing and illustrating principles of physics and their quantitative relations. The numbers employed are such as to make the arithmetical work easy. It is an excellent set of problems; though some teachers may wish it contained more purely qualitative questions on physical phenomena.

The text is thoroughly teachable, comprehensive, up-to-date, and one of the best that has appeared. W. E. T.

The Appleton Arithmetics, by J. W. A. Young, Ph.D., Associate Professor of the Pedagogy of Mathematics, the University of Chicago, and Lambert L. Jackson, Ph.D., formerly Professor of Mathematics, State Normal School, Brockport, N. Y. D. Appleton & Co. 1909.

The Primary Book, pp. 264, planned to cover the first four years' work, is written from the standpoint of the child. The problems and illustrations are based on the child's games, purchases, and possessions, and on his knowledge of form, measurement, and comparison. The type is large and clear, and the pages are made attractive by open spacing and by an abundance of illustrations, diagrams, and tables. The important principles of arithmetic are developed by suggestive illustrations, questions, and statements, called "Preparatory Work." There are frequent and systematic reviews, the oral and written work is well classified, and many suggestions are made as to the form of the calculations.

The Grammar School Book, 450 pp., covers the four years of work usually taught in the fifth, sixth, seventh, and eighth grades. "In addition to giving proper attention to the culture value peculiar to the exact reasoning of school mathematics, this book recognizes the utility of arithmetic. The problem material is rich in data drawn from the pupil's experience. School subjects like manual training, domestic art, geography, nature study, and drawing have furnished many problems; and the everyday occupations and industries of the average community are made to contribute their share of applications. Finally, the larger interests of the community, such as production, transportation, communication, and government, have not been neglected as sources for problems of interest and value." Literal numbers, the equation, and simple geometrical relations have been introduced and are made a real part of the arithmetic work. In this book also, the diagrams and illustrations are a noticeable feature. These arithmetics are model text-books; useless material has been discarded and the new material has been chosen wisely and introduced skillfully, so that both teacher and pupil can accomplish much with a small amount of drudgery. H. E. C.

First Principles of Chemistry, by Brownlee and others. Allyn and Bacon, publishers.

It is always a pleasure to look over a new text-book on elementary chemistry. Several new or revised texts have come out during the last four or five years and one notes with satisfaction the general improvements which have been made. The "First Principles of Chemistry" by Brownlee and others seems to take first rank among elementary texts as an embodiment of the most modern ideas on chemistry teaching.

There is no dispute among science teachers that the study of chemistry is usually difficult for beginners. A pupil who works under ordinary conditions is not easily interested in this study at the outset, and consequently the work does not progress as smoothly as it should. in a nutshell, the reason for this lies in the fact that a certain amount of work must be done before enough facts and fundamental ideas can be presented to the beginner for him to see some connection in the subject as a whole. For this reason it is of extreme importance that we should put into the hands of the student a text-book which, in the first place, is written in an easy style, which in the second place at all times keeps well to the prime object of high school chemistry, namely: the presentation of chemical laws and ideas and their corroboration by means of experiments and illustration; which in the third place holds and stimulates the interest of the reader and brings out the value and importance of this study by referring to practical applications in everyday and industrial life. The text-book by Brownlee and others fulfills these requirements at every step. This book derives chemical laws, both general and specific, in a clear, concise, and logical manner, it constantly impresses the reader with the fact that chemistry is a composite whole and not merely a study of a number of scattered facts brought out and illustrated by spectacular experiments. The eminent Dr. J. W. Richards says of it: "A remarkable book. The most reasonable and accurate elementary chemistry that I know of."

To the student the concise summary at the conclusion of each chapter is of general benefit for the rounding out of the knowledge gained and of special benefit in reviewing either any special chapter or the whole book. The summary presents an excellent skeleton of the subject and the reading matter furnishes the details on any particular point.

The list of exercises at the end of each chapter furnishes a good method of leading students to think for themselves, and to apply the knowledge gained from the text. In scientific work especially the habit of original thought and the application of material gathered is of paramount importance.

The photographic work and the accurate yet simple drawings deserve special mention. Good cuts always carry a peculiar weight in an elementary text. They are likely to cause immediate interest in the book.

The method of writing a chemical reaction, indicating by means of an arrow the direction in which the action goes on is unique and an improvement over the general method of using equality marks. The idea of an equation is certainly not lost by using the arrow and the

advantage gained can easily be noticed when we represent a chemical action which may go in either direction, depending on different physical conditions. Again in the discussion of reversible reactions when due to mass action this method of writing is decidedly indicative of actual results.

The tables and lists in the Appendix are perhaps more complete, and consist of more special information than any other elementary book on the subject.

In general the book by Brownlee and others inspires and appeals to better work in chemistry in that it interests the student. It brings out the fnudamental ideas on which organic, inorganic and physical chemistry are based. Chapter XXIII on Carbon and Chapter XXXV on Carbon Compounds form an excellent introduction to organic chemistry. The stress laid on chemical calculations in detail and the full discussions on the metallurgy of metals lay lasting foundations for conceptions of quantitative relations in chemistry. The able treatment of the ionization theory and electrolysis (Chapter XV) and the practical applications of these theories in the industrial world (Chapter XVI) on "Sodium and Potassium Compounds," Chapter XXVIII on "Copper and Its Compounds," and Chapters XXIX and XXXI on the methods and value of gold, silver, nickel, and copper plating introduce nicely that all-important branch of physical chemistry which we call electro chemistry. Furthermore, the newest developments of electro chemistry in connection with the electric furnace are properly shown in Chapter XIV on "Sodium and Potassium," Chapter XXX on "Aluminum and Its Compounds," Chapter XXV on "Silicon and Boron," Chapter XXIII on "Carbon," with special mention of graphite and the carbides. The possibilities, the economy and the applications of electro chemistry are admirably treated.

The authors of the book show excellent judgment in their discussions on what is commonly called the theoretical part of chemistry. In Chapter VII on "Atoms and Molecules," Chapter X on "Molecular Composition," Chapter XI on "Atomic and Molecular Weights," Chapter XV on "Solution," etc., we find discussions which are accurate and complete yet simple enough for ordinary students to grasp readily. Dr. C. F. Chandler of Columbia University says of the book: "I have never seen chemical laws presented in a simpler or clearer manner."

The claims of the authors as stated in the preface to the book are accurately fulfilled. These are: (1) That the experimental evidence precedes the chemical theory and that when sufficient facts have been given to make explanation necessary, generalizations of the science have been introduced; (2) that the historic order is followed in developing the theory, and (3) that the practical aspects of the science are emphasized by giving the pupil some idea of the great commercial importance of chemistry.

Furthermore the book has many features which make it an interesting text in the hands of the pupils and a valuable assistant to the instructor. Last session six of the reviewer's students became so interested in the book when special discussions were read to them that they borrowed it, "read nearly all of it and found it fine."

R. C. PANTERMUEHL.